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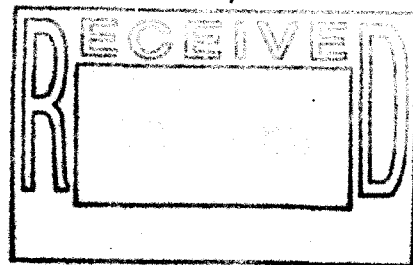
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Final Draft
Ecological Risk Assessment Methodology

Technical Memorandum No. 2
Sitewide Conceptual Model

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Golden, Colorado



February 1995

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B	Woman Creek Drainage Basin Potential Contaminants of Concern

LIST OF ACRONYMS AND ABBREVIATIONS

AIP	Agreement in Principle
CDPHE	Colorado Department of Public Health and Environment
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cfs	cubic feet per second
cm/sec	centimeters per second
COC	contaminant of concern
d/m/L	disintegrations per minute per liter
DOE	U.S. Department of Energy
EA	Environmental Assessment
EcMP	Ecological Monitoring Program
ECOC	ecological contaminant of concern
EPA	U.S. Environmental Protection Agency
EPM	exposure pathways model
ERA	ecological risk assessment
ERAM	Ecological Risk Assessment Methodology
ERSWM	Event-Related Surface Water Monitoring
ERTSD	Environmental Restoration Technical Support Document
FFCA	Federal Facilities Compliance Agreement
g	gram
GMP	groundwater monitoring program
ha	hectare
IA	Industrial Area
IAG	Interagency Agreement
IHSS	individual hazardous substance site
IM	Interim Measure
IRA	Interim Remedial Action
ITS	Interceptor Trench System
kg	kilograms
km ²	square kilometers
mCi	microcuries
mL	milliliters
mph	miles per hour
NOAEL	no observed adverse effects level
NPDES	National Pollution Discharge Elimination System

LIST OF ACRONYMS AND ABBREVIATIONS

(continued)

NRPCP	Natural Resource Protection and Compliance Program
OU	operable unit
PA	Protected Area
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
pCi/L	picocuries per liter
PCOC	potential contaminant of concern
PF	problem formulation
RCRA	Resource Conservation and Recovery Act
RFEDS	Rocky Flats Environmental Database System
RFETS	Rocky Flats Environmental Technology Site
RFI	RCRA Facility Investigation
RI	Remedial Investigation
SCM	Sitewide Conceptual Model
SCS	Soil Conservation Service
SEA RAM	Systems Engineering Analysis Risk Assessment Methodology
SID	South Interceptor Ditch
SOP	standard operating procedure
STP	Sewage Treatment Plant
SVOC	semivolatile organic compound
TAL	target analyte list
TM	Technical Memorandum
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound

EXECUTIVE SUMMARY

The Sitewide Conceptual Model Technical Memorandum (TM2) is the second of three technical memoranda that summarize the general approach and methods used in ecological risk assessments (ERAs) at the U.S. Department of Energy (DOE) Rocky Flats Environmental Technology Site (RFETS) near Golden, Colorado (Figure 1-1). The TMs describe the universal methodology and assumptions for design and implementation of ERAs at RFETS. TM1, Assessment Endpoints, describes the general technical approach and scope of the ERAs and presents the assessment endpoints (Suter 1989, EPA 1994), which are the focus of data collection and analysis for ERAs at RFETS. TM1 also describes the overall process for conducting ERAs at RFETS and the roles that each of the three TMs should play in the process. TM2 provides information to be used in the problem formulation phase of the ERA, including a description of the environmental setting, contaminant pathways, exposure pathways, receptor guides, exposure parameters, and measurement endpoints. It also summarizes existing environmental data, data sources, and ongoing monitoring programs. TM3, Ecological Contaminant of Concern (ECOC) Screening Methodology, presents the methodology for screening site data to determine which chemicals should be evaluated in a specific ERA. TM3 describes the process for identification of ECOCs and describes the process for evaluating risks if no ECOCs are identified.

Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) activities at RFETS are currently based on 16 operable units (OUs) (Section 3.0), each containing several contaminant source areas, designated as individual hazardous substance sites (IHSSs). For the purposes of conducting RFI/RI Baseline ERAs, RFETS has been divided into four areas: the Industrial Area/Protected Area (IA/PA); the Woman Creek drainage basin; the Walnut Creek drainage basin; and the Offsite Areas, which include Great Western Reservoir, Mower Reservoir, and Standley Lake (Figure 1-3). Each of the drainages contains source areas associated with several OUs, and a given OU may contribute to contaminant transport in both drainages (Figure 1-3). Thus, it is not feasible to conduct an ERA for a single OU without considering the effects of other OUs on the drainage.

The focus of baseline ERAs at RFETS is on chemical stressors and their potential effects. This is consistent with EPA guidance on conducting ERAs at Superfund sites (EPA 1994). Physical and biological sources of stress will also be considered in ERAs where appropriate for evaluating sources for cumulative impacts or effects of proposed remedial and/or reclamation tasks.

Development of a sitewide conceptual model (SCM) is a step in the problem formulation (PF) phase of ERAs conducted for Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) RIs (EPA 1994). The purpose of the SCM is to help identify environmental stressors and the potential pathways by which ecological receptors may be exposed to them. This step allows investigators to identify the potentially complete pathways that will become the focus of the ERA. The SCM also aids in the selection of measurement endpoints for use in evaluation of assessment endpoints (Suter 1993, also see TM1).

TM2 does not constitute the PF phase for any of the baseline ERAs. Rather, the following basic information required to implement the PF phase is provided (EPA 1992, 1994):

- A description of the environmental setting at RFETS, including the natural physical and biological systems and a brief description of the primary contaminant source areas or IHSSs
- A description of the important contaminant fate and transport pathways in abiotic media
- A description of the important exposure pathways, including primary exposure media, exposure points, receptor guilds, and exposure routes
- A description of receptor guilds and identification of key species in each guild to be used in representative exposure estimates at RFETS
- Species-specific exposure parameters to be used in estimating exposure to key receptors
- Measurement endpoints for which data have been collected

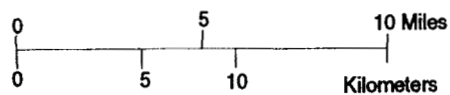
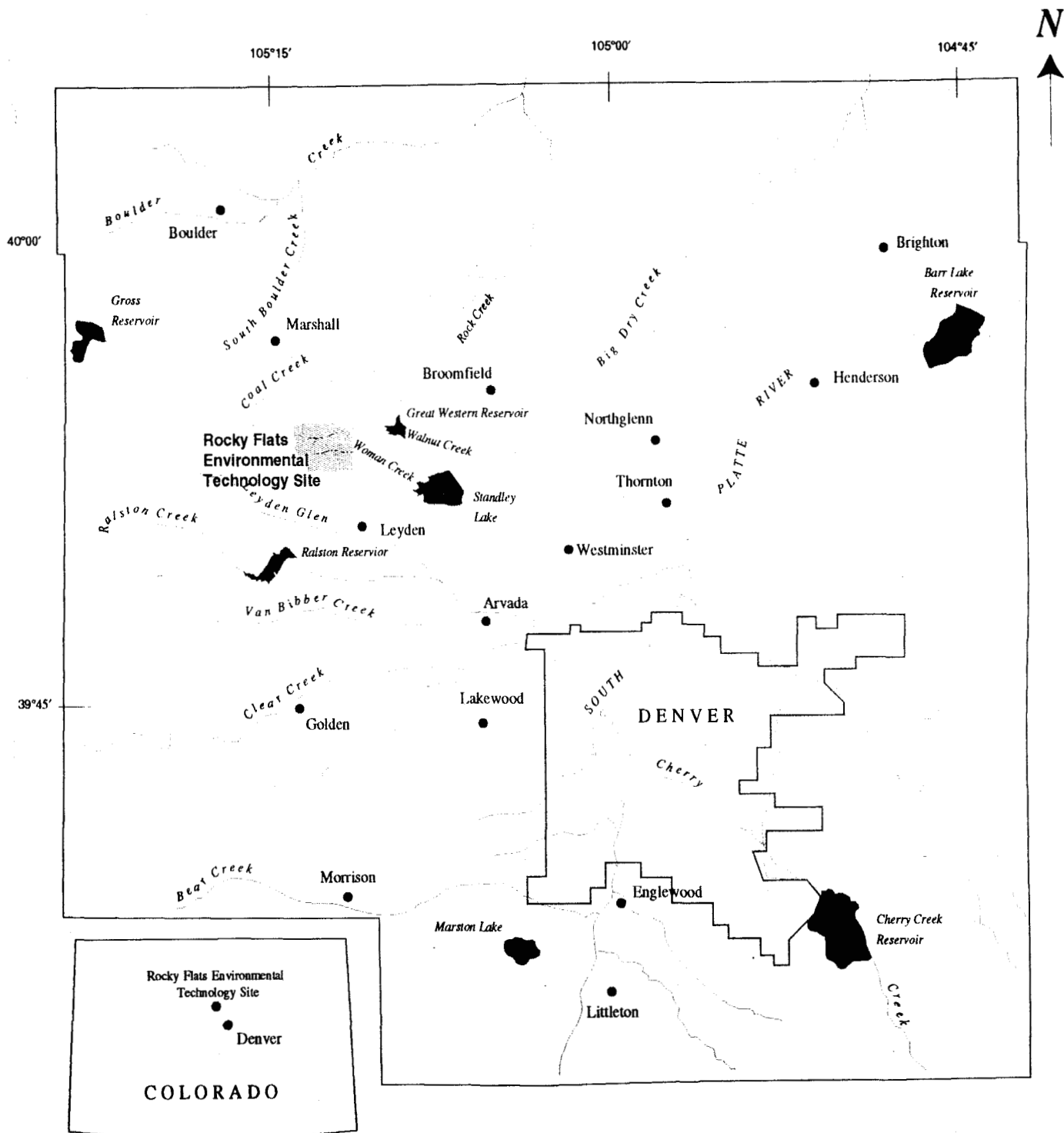
TM2 also summarizes existing environmental data, data sources, and ongoing monitoring programs. The information in TM2 will be periodically updated through revisions to TM2 or addition of appendices as new data become available. Official revisions or amendments to TM2 will be controlled through RFETS standard document control procedures and available from the EG&G Document Control Center.

1.0 INTRODUCTION

The Sitewide Conceptual Model Technical Memorandum (TM2) is the second of three technical memoranda that summarize the general approach and methods used in ecological risk assessments (ERAs) at the U.S. Department of Energy (DOE) Rocky Flats Environmental Technology Site (RFETS) near Golden, Colorado (Figure 1-1). The TMs describe the universal methodology and assumptions for design and implementation of ERAs at RFETS. TM1, Assessment Endpoints, describes the general technical approach and scope of the ERAs and presents the assessment endpoints (Suter 1989, EPA 1994), which are the focus of data collection and analysis for ERAs at RFETS. TM1 also describes the overall process for conducting ERAs at RFETS and the roles that each of the three TMs should play in the process. TM2, Sitewide Conceptual Model (SCM), provides information to be used in the problem formulation phase of the ERA, including a description of the environmental setting, contaminant pathways, exposure pathways, receptor guides, exposure parameters, and measurement endpoints. It also summarizes existing environmental data, data sources, and ongoing monitoring programs. TM3, Ecological Contaminant of Concern (ECOCs) Screening Methodology, presents the methodology for screening site data to determine which chemicals should be evaluated in a specific ERA. TM3 describes the process for identification of ECOCs and describes the process for evaluating risks if no ECOCs are identified.

There is a significant overlap in scope and content between the Systems Engineering Analysis Risk Assessment Methodology (SEA RAM) (EG&G 1994b) and the Ecological Risk Assessment Methodology (ERAM) being developed to support the RI/FS process and the Baseline Risk Assessment Required under CERCLA/RCRA, NCP, and the IAG. Like the ERAM, SEA RAM is a traditional risk assessment methodology. The objective is to develop and implement a computer-based methodology for comparing potential impacts to human health and the environment from chemical exposures under both current and future uses of RFETS (EG&G 1994b).

The ERAM goals are similar to the SEA RAM. However, the ERAM is based on site-specific data and results in in-depth guidelines tailored to perform ERAs at RFETS. In addition, the ERAM is being developed cooperatively with CDPHE and EPA. A comparison of the major components of the SEA RAM and ERAM methodologies are listed in Table 1-1.



U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

Final Draft
Ecological Risk Assessment Methodology
Technical Memorandum No. 3
Ecological Contaminant of Concern Screening
Methodology

Location of Rocky Flats
Environmental Technology Site

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Figure 1-1

Table 1-1
Comparison of SEA RAM and ERAM Major Components

SEA RAM Major Components	Component Locations in ERAM Documents	Remarks
Identify key species	ERAM TM2	
Identify major COCs	ERAM TM3	ERAM includes procedures for identifying ECOCs using site-specific data
Identify exposure pathways	ERAM TM2	
Define methodology for ranking potential exposures and risks to ecological receptors using the DARA (Decision Analysis/Risk Analysis) Model	Problem Formulation	A specific Problem Formulation TM is developed in the ERAM
Identify ecological benchmark values for COCs	ERAM TM3	Ecotoxicological benchmarks used in the ERAM are developed with involvement of EPA
Define Hazard Quotients (HQs) for chemicals, media, and species of interest using the Quotient Method	Problem Formulation	
Define Hazard Index Methodology for combining HQs for a given species and for different chemicals or media	ERAM TM3	
Develop Cumulative Methodology for evaluating ecological risks from different types of site-specific studies	Problem Formulation	Problem Formulation TM associated with a specific ERA

Development of a site conceptual model is identified by the U.S. Environmental Protection Agency (EPA) as a step in the problem formulation (PF) phase of ERAs conducted for Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Remedial Investigations (RIs) (EPA 1994). The purpose of the SCM is to help identify environmental stressors and the potential pathways by which ecological receptors may be exposed to them. This step allows investigators to identify the potentially complete pathways that will become the focus of the ERA. The SCM also aids in the selection of measurement endpoints for use in evaluation of assessment endpoints (Suter 1993, also see TM1).

NOTE: EPA has drafted a guidance document to expand on the "Framework for Ecological Risk Assessment" (EPA 1992). The guidance document (EPA 1994) is currently in a review draft format that has not been formally released but is available. The ECOC screening process described in TM3 is based, in part, on the draft guidance. Specifically, assumptions used in the Tier 2 ECOC screen are consistent with the Preliminary Risk Calculation (Step 2) section. Prior to preparation of this TM, EPA ecotoxicologists were informally consulted in the proper use and citing of the guidance document in its current form. DOE understands that the guidance is preliminary but wishes to comply with the "spirit" of the process defined in it.

EPA (1992, 1994) identifies three main categories of environmental stressors: physical, chemical, and biological. Although physical and biological stressors may occur at RFETS, the focus of baseline ERAs at the site is on chemical stressors and their potential effects because of the following circumstances:

- Chemical stressors are usually of greatest concern for ERAs conducted as part of CERCLA investigations (EPA 1994). OSWER Directive 9285.7-17 states that the overall objectives of baseline ERAs for CERCLA are to identify and characterize the current and potential threats to the environment from a hazardous substance release and establish cleanup levels that will protect natural resources at risk.
- The motivation for ERAs conducted for the RCRA Facility Investigation (RFI)/RI process at RFETS is generally "source-driven" because there are apparent contaminant sources, but exposures and effects are not known (Suter 1993). Therefore, a primary focus of baseline ERAs is to evaluate contaminant transport,

estimate current and future exposures to site contaminants, and evaluate the potential ecotoxicity of these exposures.

The boundaries of RFETS include portions of the headwater areas of three drainages: Rock Creek, Walnut Creek, and Woman Creek (EG&G 1994a) (Figure 1-2). All manufacturing, processing, and waste disposal activities, and therefore all potential contaminant source areas, have been restricted to areas of the Walnut Creek and Woman Creek drainages.

Most environmental investigations at RFETS are currently based on 16 operable units (OUs) (Section 3.0). Each OU contains several contaminant source areas. Each of the drainages contain source areas associated with several OUs, and a given OU may contribute to contaminant transport in both drainages (Figure 1-3). Thus, it is not feasible to conduct an ERA for a single OU without considering the effects of other OUs on the drainage. Therefore, the ecological risk assessment strategy for the site was redesigned to assess risk for larger areas that represent more ecologically distinct units.

RFI/RI baseline ERAs will be conducted for four main areas associated with RFETS: The Industrial Area/Protected Area (IA/PA); the Woman Creek drainage basin; the Walnut Creek drainage basin; and the Offsite Areas, which include Great Western Reservoir, Mower Reservoir, and Standley Lake (Figure 1-3). The IA/PA is a highly developed area containing limited ecological resources but which sits atop the topographic divide between the headwater areas of Woman Creek and Walnut Creek and may serve as a source for transport of contaminants into the drainages. The Woman Creek and Walnut Creek drainages each include source areas in several OUs for which independent RFI/RI studies are being conducted as part of sitewide environmental investigation and cleanup efforts. The reservoirs included in the Offsite Areas receive flow from Woman Creek or Walnut Creek.

The TM2 does not constitute the PF phase for any of the baseline ERAs. Rather, the following basic information required to implement the PF phase is provided (EPA 1992, 1994):

- A description of the environmental setting at RFETS, including the natural physical and biological systems and a brief description of the primary contaminant source areas or individual hazardous substance sites (IHSSs)
- A description of the important contaminant fate and transport pathways in abiotic media

- A description of the important exposure pathways, including primary exposure media, exposure points, receptor guilds, and exposure routes
- A description of receptor guilds and identification of key species in each guild to be used in representative exposure estimates at RFETS
- Species-specific exposure parameters to be used in estimating exposure to key receptors
- Measurement endpoints for which data have been collected

TM2 also summarizes existing environmental data, data sources, and ongoing monitoring programs. The information in TM2 will be periodically updated through revisions to TM2 or addition of appendices as new data become available. Official revisions or amendments to TM2 will be controlled through RFETS standard document control procedures and available from the EG&G Document Control Center.

The information in TM2 will be used in conjunction with data on nature and extent of contamination, selected assessment endpoints, and COC screening methodologies to complete the PF phase for each ERA. The PF will be documented in a PF TM, which will be submitted to EPA and the Colorado Department of Public Health and Environment (CDPHE) for review.

2.0 SITE DESCRIPTION

This section describes the physical setting and general ecology of RFETS. Ecological descriptions are organized by watershed to correspond to the organization of the ERAs. The level of detail presented should enable the reader to identify major habitat types. More detail and quantitative analyses will be included in the PF TM and in individual ERA reports.

2.1 Physical Features

2.1.1 Physiography and Topography

The natural environment of RFETS and vicinity is influenced primarily by its proximity to the Front Range of the Southern Rocky Mountains. RFETS is located less than 2 miles east of the north-south trending Front Range and approximately 16 miles east of the Continental Divide. This transition zone between prairie and mountains is referred to as the Colorado Piedmont section of the Great Plains Physiographic Province (Thornbury 1965, Hunt 1967).

The Colorado Piedmont is an area of dissected topography reflecting folding and faulting of bedrock along the edge of the Front Range uplift, subsequent pediment erosion and burial by fluvial processes, and more recent incision of drainages and removal of portions of the alluvial cap. Rocky Flats is the most extensive pediment in the area. RFETS occupies the eastern edge of this pediment, which extends approximately 5 miles northeast from the mouth of Coal Creek Canyon. The surface of RFETS lies at an elevation of approximately 6,000 feet above mean sea level. In eastern portions of RFETS, the nearly flat pediment gives way to lower, more rolling terrain.

2.1.2 Surficial Geology

Seven distinct surficial deposits of Quaternary age are present at RFETS: Rocky Flats Alluvium, younger Verdos and Slocum alluviums, undifferentiated terrace deposits, colluvium, landslide deposits, and valley-fill (Piney Creek) alluvium (Plate 2-1). Additional surficial materials at the site include fill used in construction.

Rocky Flats Alluvium is both the oldest and most extensive surficial unit at the site. Rocky Flats Alluvium, which has been dated at 1 to 2 million years (pre-Wisconsin), is described as an angular to subrounded, poorly sorted, coarse, bouldery gravel in a sand matrix with lenses of clay, silt, and varying amounts of caliche. Lithic (rock) fragments are composed primarily

of quartzite derived from Coal Creek Canyon. Igneous and sedimentary fragments are also present. This material forms a blanket-like deposit averaging 10 to 20 feet thick across the broad upland surface in the western portion of the site and on ridges between drainages (interfluves) in the central and eastern portions.

Younger pre-Wisconsinan terraces (i.e., the Verdos Alluvium and Slocum Alluvium) occur east of the extent of Rocky Flats Alluvium at lower elevations in the eastern part of the site. These deposits, and the younger undivided terraces shown on Plate 2-1, consist of reworked Rocky Flats Alluvium and some bedrock.

Hillsides between the narrow interfluves and valley floors are cloaked with a mantle of either colluvium or landslide deposits (Plate 2-1), depending on the amount of movement interpreted by the geologist(s) involved in the mapping (Shroba and Carrara 1994). Colluvium consists of material from the caprock (e.g., Rocky Flats Alluvium or Arapahoe Formation) that is moving downward across a stable slope. Thicknesses vary from 0 to 20 feet. Landslide deposits imply that the underlying slopes have been unstable in the past and show signs of movement (e.g., slump blocks).

Valley-fill alluvium of Piney Creek (Holocene) age occurs along the floors of most drainages. These deposits consist primarily of reworked alluvium of older ages, along with some bedrock. Valley-fill alluvium is mostly a poorly sorted sand and gravel in a silty clay matrix. Thicknesses range from 10 to 40 feet across most of the site.

2.1.3 Bedrock Geology

Rocky Flats Alluvium is unconformably underlain by (from youngest to oldest) the Arapahoe Formation, Laramie Formation, Fox Hills Sandstone, and Pierre Shale, all of Late Cretaceous age. These units represent approximately 9,100 feet of material beneath the site. A generalized stratigraphic column is shown as Figure 2-1.

The Arapahoe Formation is approximately 250 feet thick in the vicinity of RFETS, but only the lower 50 feet (or less) are present onsite. The Arapahoe Formation consists of fluvial claystone and silty claystone interbedded with discontinuous fluvial sandstone units. The sandstones are very fine- to medium-grained and moderately sorted. The basal unit overlying the Laramie Formation is locally conglomeratic.

Age	Formation	Thickness (feet)
Quaternary	Rocky Flats Alluvium/ Colluvium	0-100
Cretaceous	Arapahoe Formation	0-50
	Laramie Formation	600-800
		upper interval: 300-500
		lower interval: 300
	Fox Hills Sandstone	90-140
	Pierre Shale and older units	

Clayey Sandy Gravels – reddish brown to yellowish brown matrix, grayish-orange to dark gray, poorly sorted, angular to subrounded, cobbles, coarse gravels, coarse sands and gravelly clays: varying amounts of caliche

Claystones, Silty Claystones, and Sandstones – light to medium olive-gray with some dark olive-black claystone, silty claystone, and fine-grained sandstone, weathers yellowish orange to yellowish brown; a mappable, light to olive gray, medium- to coarse-grained, frosted sandstone to conglomeratic sandstone occurs locally at the base (Arapahoe marker bed)

Claystones, Silty Claystones, Clayey Sandstones, and Sandstones – kaolinitic, light to medium gray claystone and silty claystone and some dark gray to black carbonaceous claystone, thin (2') coal beds and thin discontinuous, very fine to medium-grained, moderately sorted sandstone intervals

Sandstones, Claystones, and Coals – light to medium gray, fine- to coarse-grained, moderately to well sorted, silty, immature quartzose sandstone with numerous claystones, and subbituminous coal beds and seams that range from 2' to 8' thick

Sandstones – grayish orange to light gray, calcareous, fine-grained, subrounded glauconitic, friable sandstone

Source: Phase II Geologic Characterization Surface Geologic Mapping Report, March 1992

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

Final Draft
Ecological Risk Assessment Methodology
Technical Memorandum No. 2
Sitewide Conceptual Model

**Generalized Stratigraphic Section for the
Rocky Flats Environmental Technology Site**

February 1995

Figure 2-1

The underlying Laramie Formation is 600 to 800 feet thick at the site and represents a transitional fluvial/deltaic/shallow marine environment. The upper interval of this unit contains claystones, siltstones, and carbonaceous claystones; thin, discontinuous, very fine- to medium-grained sandstones; and thin coal beds. The lower interval includes fine- to coarse-grained, moderately to well-sorted, silty, immature quartzose sandstones with lenticular coal beds and seams and numerous interbedded claystones.

The Fox Hills Sandstone comprises 90 to 140 feet of friable, fine-grained sandstone with interbedded sandy shales. The Fox Hills Sandstone is exposed in quarries on the western part of RFETS and on hogbacks both north and south of the site. The basal unit interfingers with the Pierre Shale, which consists of approximately 8,000 feet of marine deposits. The Pierre Shale is exposed in large areas of the South Boulder Creek and Coal Creek valleys northwest of the site.

2.1.4 Soils

The soils of the site were mapped by the Soil Conservation Service (SCS) as part of a soil survey of the Golden, Colorado, area (Price and Amen 1983) (Plate 2-2). A strong relationship exists between soils and the deposits on which they have formed. In general, soil textures at RFETS are predominately loamy with varying amounts of clay, sand, gravel, and cobbles.

The most laterally extensive soils at the site are cobbly and gravelly soils of the Flatirons-Veldkamp series. These soils, which occupy pediment surfaces, high terraces, and upper hillsides, are deep, well-drained soils that formed in stoney to gravelly and loamy material of the Rocky Flats Alluvium (Price and Amen 1983). Rock fragments compose 35 to 80 percent of the soil, by volume.

West of RFETS and in eastern portions of RFETS, the Rocky Flats Alluvium is absent, and soils have formed on bedrock materials. West of the site, the Argiustolls-Rock outcrop-Baller series soils have formed on steep ridges and hill slopes (Price and Amen 1983). These soils are predominantly well-drained, stony and loamy, and have formed in colluvium derived from sedimentary rocks.

In the eastern portion of the site, soils of the Denver-Kutch series are common and have formed on moderately sloping to steep terraces and hillslopes (Price and Amen 1983). Denver-Kutch soils are deep, well-drained, and clayey, and have formed in material derived from mudstones and shales of the Arapahoe and Laramie formations.

Surface Soil nutrient content, as well as physical parameters such as texture, moisture holding capacity, etc. may be available in the Ecological Monitoring Program (EcMP) 1995 Annual Report.

2.1.5 Surface Water

Three intermittent streams drain RFETS: Rock Creek, Walnut Creek, and Woman Creek. Rock Creek drains the northern portion of the site and flows northeastward toward its confluence with Coal Creek. Walnut Creek and Woman Creek flow eastward across the central and southern portions of the site, respectively, and are included in the Big Dry Creek drainage basin. Big Dry Creek is a tributary of the South Platte River, which it joins near Brighton, Colorado, approximately 42 miles east of the site. Figure 1-2 shows the onsite portions of the three drainage basins.

For the purposes of this report, subsequent discussions of surface water hydrology focus on Walnut Creek and Woman Creek, which have historically been influenced by production and waste disposal activities at RFETS, represent potential exposure pathways to onsite and offsite receptors, and are expected to be included in future remediation of the site. In contrast, Rock Creek is located outside the historic influence of RFETS activities and is considered to be unaffected by the facility. The following descriptions of the Walnut and Woman Creek basins are based on information previously compiled by EG&G (1991a, 1994a).

2.1.5.1 Walnut Creek

As noted above, Walnut Creek is an east-flowing, intermittent stream that drains the central portion of RFETS, including most of the industrial complex (i.e., the PA). Aggregate basin characteristics for Walnut Creek where it exits the site at Indiana Street are shown in Table 2-1. Within the site boundaries, Walnut Creek includes three major branches: South Walnut Creek, North Walnut Creek, and an unnamed tributary locally referred to as No Name Gulch (Figure 1-2). These tributary streams converge in the eastern part of the site.

Walnut Creek has its headwaters on the broad Rocky Flats pediment surface between Coal Creek and the western boundary of the site. The drainage basin upgradient of Indiana Street covers approximately 2,400 acres (3.7 square miles). Walnut Creek currently terminates in the Broomfield Diversion Canal; the creek previously flowed into Great Western Reservoir approximately 1 mile east of the site. Flows measured at Indiana Street in 1993 and 1994 ranged from 0 to 4 cubic feet per second (cfs) and were greatest during the spring (Figures 2-2

and 2-3). The stream is typically dry during much of the late summer, fall, and winter (EG&G 1993a, 1994a).

Table 2-1
Walnut Creek at Indiana Street
Aggregate Basin Characteristics

Area	3.71 square miles
Basin Length	5.7 miles
Basin slope	0.027 feet/foot
Impervious existing	14 percent
Pervious retention	0.49 inches
Impervious retention	0.10 inch
Infiltration, initial	3.75 inches/hour
Infiltration, final	0.55 inches/hour

Source: EG&G 1991b

The topography and hydrology of Walnut Creek vary considerably within the drainage basin. The western portion of the basin has low relief and a gradient of approximately 2 percent. Soils in this area are developed from coarse Rocky Flats Alluvium and have high infiltration rates.

In the central portion of the basin, channels become better developed where the tributary streams have cut through the Rocky Flats Alluvium cap into underlying bedrock. In this area, the basin has a gradient of 4 percent, and stream channels have formed gullies with sideslopes of up to 20 percent. Soils in this area are finer, having been derived from mudstones or shale bedrock or reworked alluvium (Section 2.1.4).

The eastern portion of the basin is characterized by the return to a lower gradient (2 percent) and broad valley floors with shallow sideslopes of about 5 percent. Soils in this area have low to moderate infiltration rates, resulting from the fine-grained bedrock parent material.

The three branches of Walnut Creek onsite have been modified to some extent by diversion, channelization, the construction of detention ponds, and the placement of fill material. No Name Gulch contains the present landfill and landfill pond (OU7). The pond collects seepage from the landfill and runoff from adjacent slopes. Spray evaporation is used to reduce this water volume; consequently, this pond does not discharge to No Name Gulch (EG&G 1994a).

Figure 2-2
1993 Mean Daily Discharge for Selected RFETS Surface Water Gaging Stations

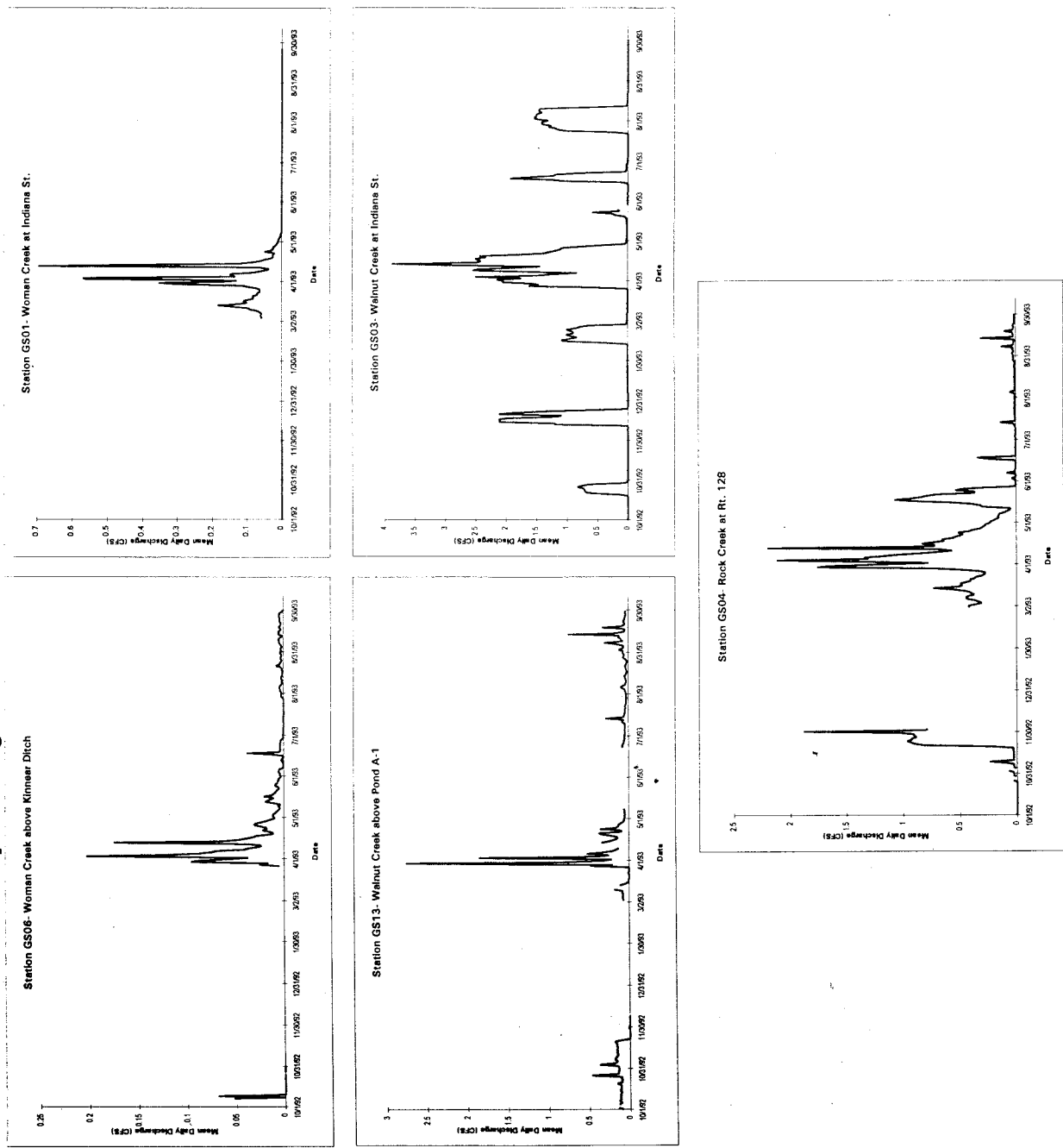
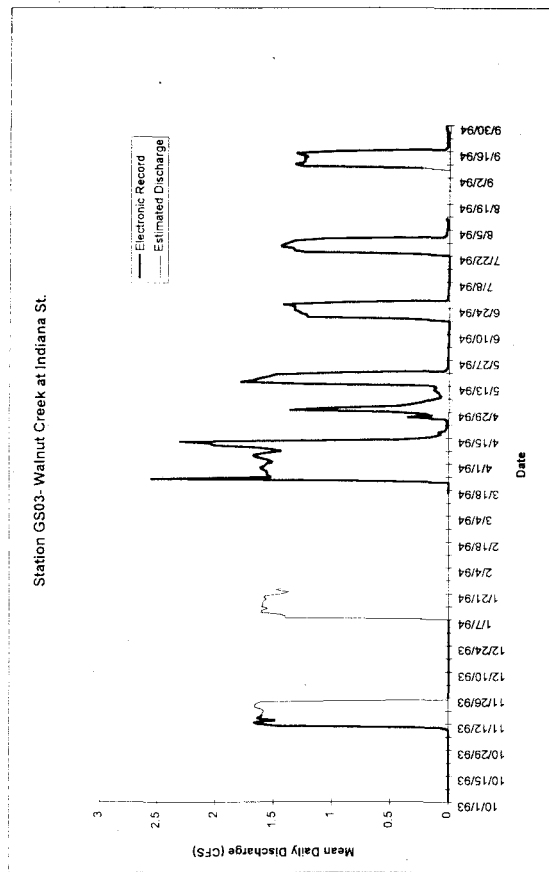
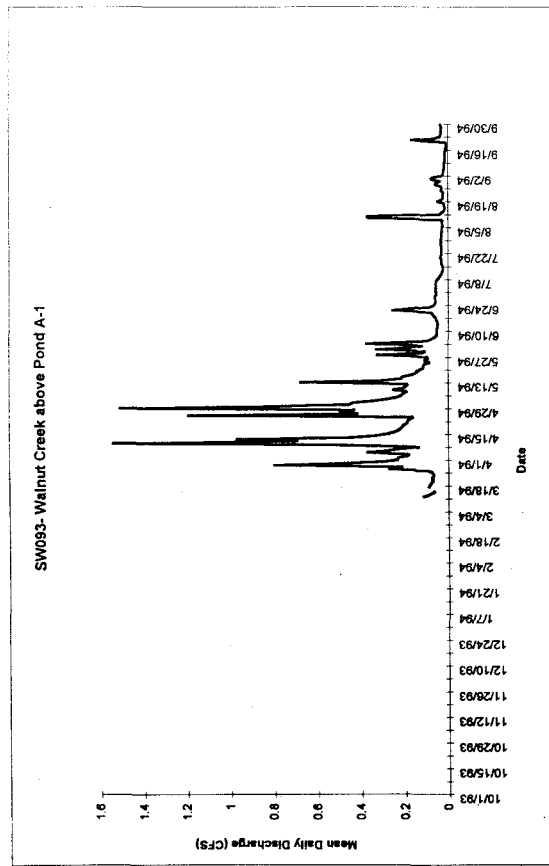
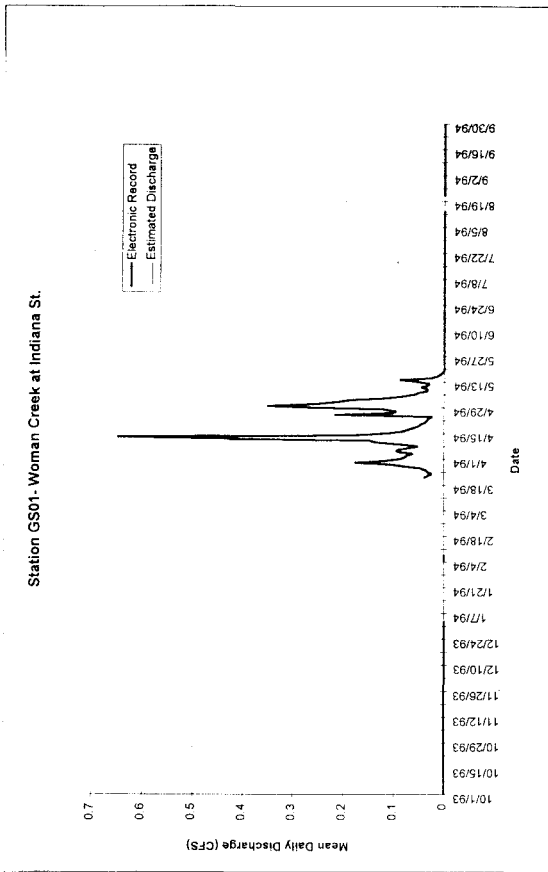
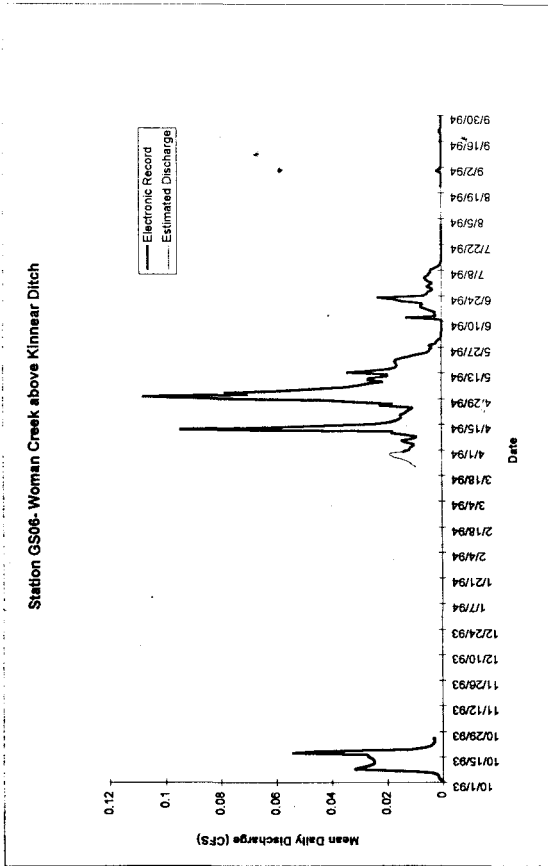


Figure 2-3
1994 Mean Daily Discharge for Selected RFETS Surface Water Gaging Stations



Four detention ponds have been constructed on North Walnut Creek as part of the runoff control and pollution prevention programs at RFETS. Ponds A-1 and A-2 retain water from adjacent slopes and spill releases (if any) within the industrial complex. These ponds do not release water directly to the creek. Water from the upper reaches of North Walnut Creek is diverted northward and eastward around the landfill and No Name Gulch and returned to North Walnut Creek downstream of Pond A-4. Runoff in the stream between the McKay Bypass and Pond A-1 is diverted via pipeline to Pond A-3. This water is then released to Pond A-4 for testing and treatment (if necessary) prior to being discharged to North Walnut Creek. This runoff control system is operated in compliance with the National Pollution Discharge Elimination System (NPDES) permit, the Federal Facilities Compliance Agreement (FFCA), and the Agreement in Principle (AIP) (EG&G 1994a). An additional pond on Walnut Creek immediately west of Indiana Street is not part of the NPDES system but is used for water measurements.

The headwaters of South Walnut Creek are contained within the PA. This drainage has been significantly altered by construction of the industrial complex and the B-series detention ponds. Currently, flow is diverted via pipeline around ponds B-1, B-2, and B-3 to Pond B-4, which in turn discharges into Pond B-5. Water from Pond B-5 is transferred via pipeline to Pond A-4, where it is tested and treated (if necessary) prior to being discharged into North Walnut Creek in compliance with the NPDES permit, the FFCA, and the AIP. These management practices result in frequent significant water-level fluctuations for the lower A- and B-series ponds, particularly ponds A-4 and B-5 (Figures 2-4 and 2-5). Ponds B-1 and B-2 receive runoff from adjacent slopes and do not discharge to the creek. Pond B-3 currently receives effluent from the RFETS Sewage Treatment Plant (STP) via pipeline.

2.1.5.2 *Woman Creek*

The Woman Creek basin covers 2,900 acres (4.5 square miles) upgradient of Indiana Street (Table 2-2). This east-flowing stream system drains the southern portion of the site and extends eastward to Standley Lake. Currently, most of the flow in Woman Creek is diverted via the Mower Ditch into Mower Reservoir east of Indiana Street. Water that is not collected by the ditch, or that overflows the Mower Diversion, continues toward Standley Lake.

The headwaters of this drainage system are on the Rocky Flats pediment southwest of the site. In its upper reaches, Woman Creek consists of two branches. The northwestern channel receives water from surface runoff, shallow groundwater, the Kinnear Ditch, and leakage in the Boulder Diversion Ditch crossover structure. The southwestern channel receives water from runoff and shallow groundwater, as well as water from Rocky Flats Lake via Smart Ditch No. 2.

Figure 2-4
1993 Pond A-4 Water Elevation

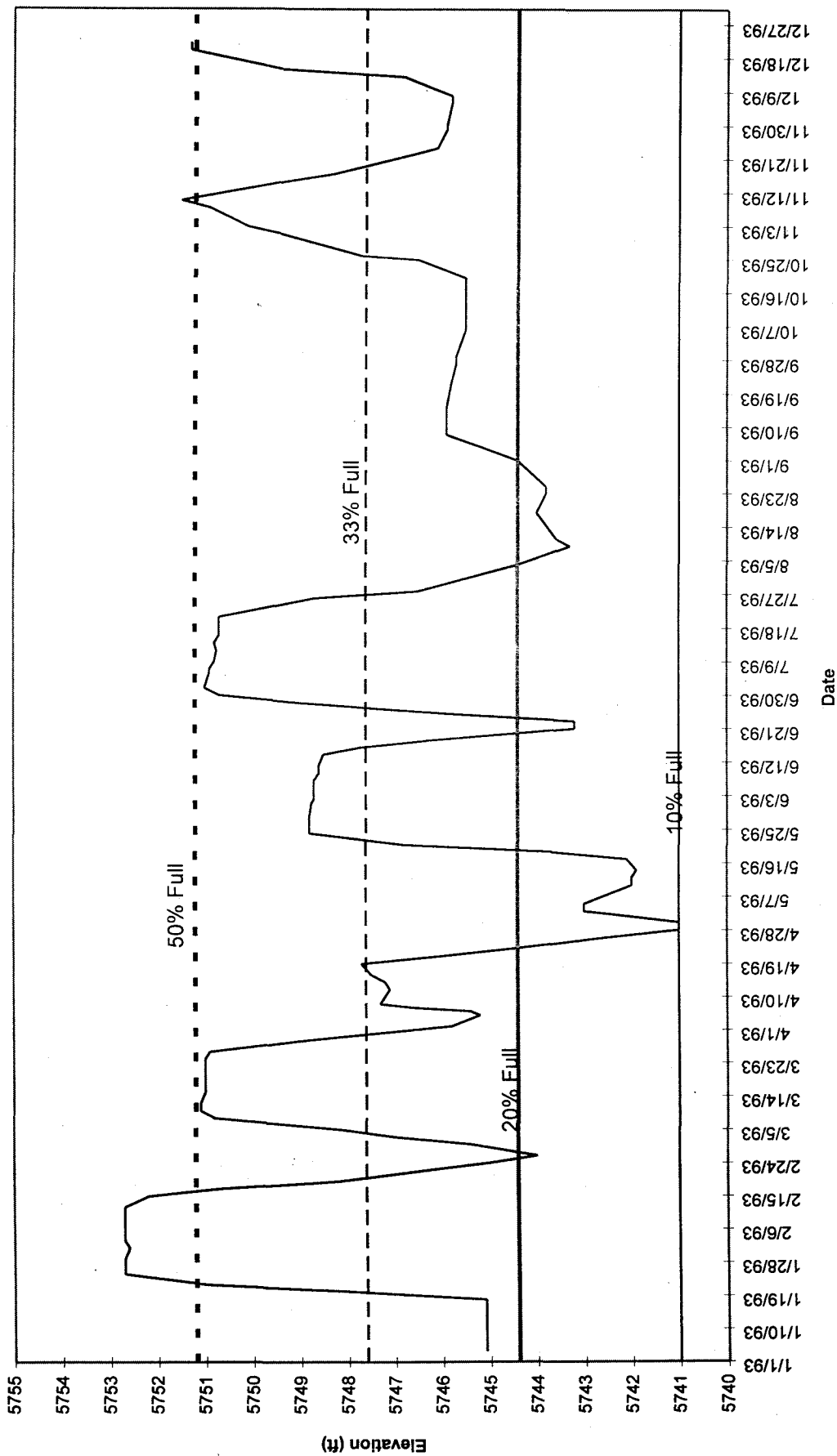


Figure 2-5
1993 Pond B-5 Water Elevation

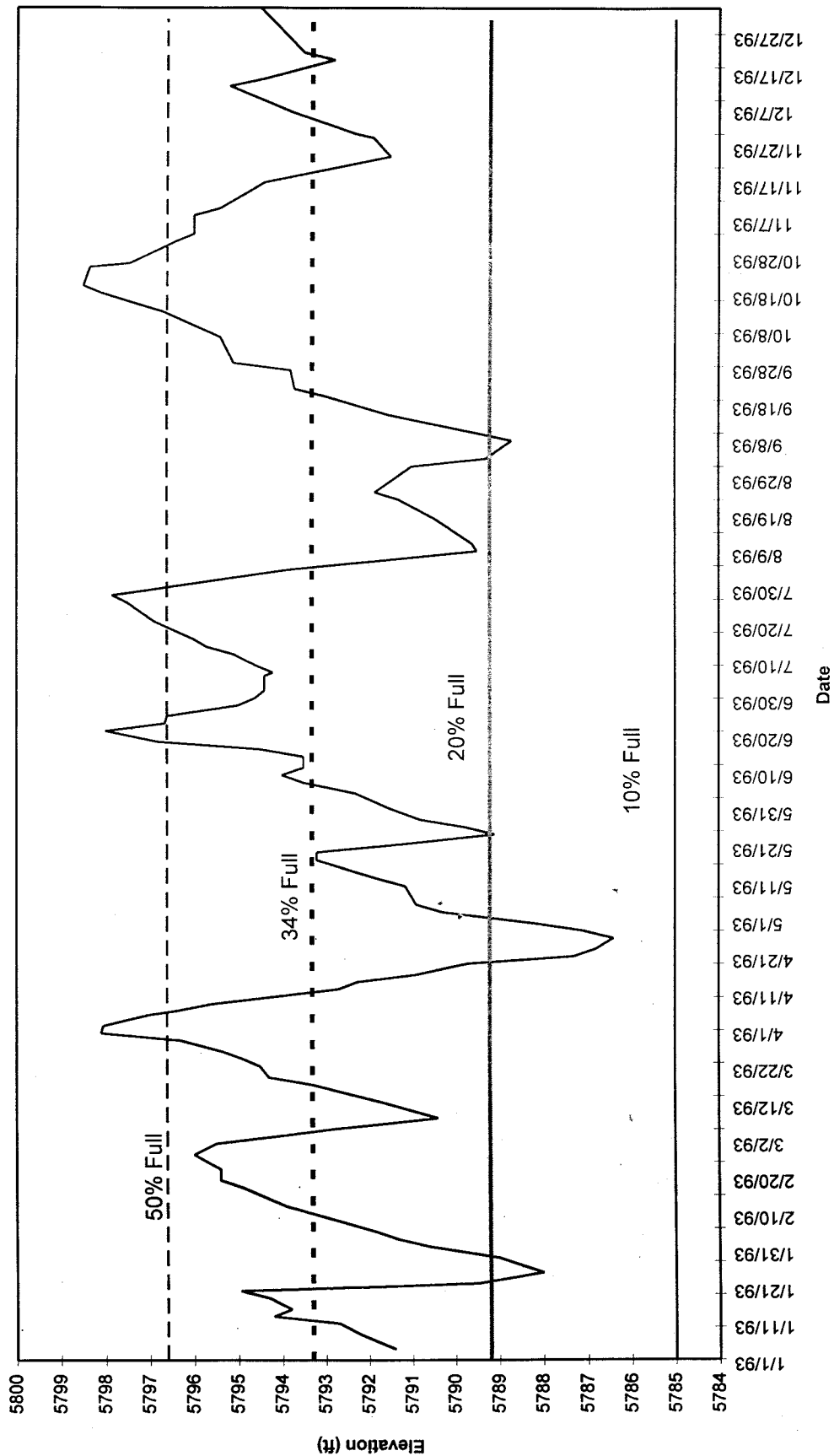


Table 2-2
Woman Creek at Indiana Street
Aggregate Basin Characteristics

Area	4.51 square miles
Basin Length	5.68 miles
Basin slope	0.028 feet/foot
Impervious existing	2 percent
Pervious retention	0.52 inches
Impervious retention	0.10 inch
Infiltration, initial	3.64 inches/hour
Infiltration, final	0.55 inches/hour

Source: EG&G 1991b

The South Interceptor Ditch (SID), however, does not converge with Woman Creek. Instead, water from the SID is stored in Pond C-2. The two branches of Woman Creek converge approximately 1.5 miles east of Colorado Highway 93 (Fedors and Warner 1993).

In most respects, the Woman Creek basin is very similar to the Walnut Creek basin. Upper reaches are characterized by shallow or indistinct channels and a low gradient. Soils in this area have high infiltration rates that reflect their origin from coarse Rocky Flats Alluvium. Middle reaches are more incised and have both steeper gradients and steeper sideslopes. In its lower reaches, beyond the Rocky Flats terrace escarpment, the stream occupies a broad, gently sloping valley. Soils in the middle and lower reaches of the basin have low infiltration rates as a result of their having been derived from fine-grained bedrock or reworked alluvium. Flows in Woman Creek at Indiana Street in 1992 varied from 0 to 0.7 cfs (EG&G 1993a, 1994a). As with Walnut Creek, flows are typically highest in the spring, and much of the stream channel is dry during late summer, fall, and winter (Figures 2-2, 2-3, and 2-6).

Two detention ponds have been constructed on the historic Woman Creek channel. Pond C-1 has a limited storage capacity and is used primarily for flow measurements. Pond C-2 does not currently receive flows from Woman Creek. Instead, a diversion structure immediately upgradient of Pond C-2 intercepts Woman Creek water and carries it around the pond. A short distance after re-entering the stream channel below Pond C-2, Woman Creek water is diverted into Mower Ditch. At present, the source of water in Pond C-2 is the SID, which intercepts runoff from the industrial complex. The SID parallels Woman Creek on the hillside to the north

before curving into Pond C-2. After the diverted runoff has been carried into Pond C-2, it is tested and treated (if necessary) prior to being discharged into the Broomfield Diversion Canal.

The unnamed drainage to the south of Woman Creek historically was a tributary that joined Woman Creek just west of Indiana Street. During earlier agricultural activities in the southeastern portion of the site, flows in this drainage, which are augmented by water from Rocky Flats Lake via Smart Ditch No. 1, were diverted away from Woman Creek toward the southeastern corner of the site. This water flows through ponds D-1 and D-2, which are not part of the RFETS runoff control or pollution prevention system. Ponds D-1 and D-2 may be used as potential reference ponds for evaluation of the effects of contaminants versus the influence of pond management on measurement endpoints.

2.1.5.3 Rock Creek

The Rock Creek drainage is located entirely outside the limits of the industrial complex and associated waste storage or disposal areas at RFETS and has remained essentially undisturbed. The portion of the basin south of State Highway 128, which forms the northern boundary of the site in this area, is approximately 1,660 acres (2.9 square miles). A northeast-trending ridge separates the Rock Creek drainage from the adjacent Walnut Creek system to the south. Rock Creek flows northeastward to its confluence with Coal Creek. Measurements in 1993 show flows ranging from 0 to 2.3 cfs, with peak flows in the spring (EG&G 1994a). An old farm pond at the abandoned Lindsay Ranch site provides aquatic habitat.

Because Rock Creek does not receive runoff from RFETS industrial or storage/disposal areas, its waters are not included in the NPDES permit for the site.

2.1.6 Groundwater

Groundwater at RFETS occurs in Quaternary surficial materials (Rocky Flats Alluvium, colluvium, and valley-fill alluvium) and in underlying Cretaceous sedimentary bedrock (claystones, siltstones, sandstones). Groundwater present in surficial materials and the upper weathered section of bedrock units is generally under unconfined conditions. Groundwater present in bedrock aquifers beneath the upper weathered section may be under either confined or unconfined conditions, depending on local conditions.

Recharge to the surficial materials groundwater system occurs as infiltration of incident precipitation and percolation from streams, ditches, and ponds. Onsite discharge of groundwater

from these shallow aquifers occurs as seeps and springs and as base flow to streams. Groundwater may also migrate offsite as subsurface flow. The surficial materials groundwater system shows substantial changes in water level in response to seasonal patterns of recharge. Recharge is greatest in the spring and early summer, when rainfall and stream flow are at a maximum and moisture levels are greatest in surficial materials (e.g., soils). Saturated thicknesses are lowest from late summer through early winter, when stream flow, precipitation, and soil moisture are lowest.

The most extensive alluvial aquifer onsite is the Rocky Flats Alluvium, which is highly permeable due to the prevalence of coarse materials. The geometric mean of hydraulic conductivities measured in the Rocky Flats Alluvium is 2.06×10^{-4} centimeters per second (cm/sec) (EG&G 1995). General flow in this unit is from west to east along the regional slope of the topography and underlying contact with bedrock units. Secondary flow directions in the Rocky Flats Alluvium are from high terraces toward the east-flowing drainages. Unconfined flow in other surficial deposits, such as colluvium and valley-fill alluvium, is generally controlled by surface and bedrock topography.

The weathered bedrock aquifers of upper sections of the Arapahoe and, less extensively, Laramie formations have hydraulic properties and flow patterns similar to those of the overlying surficial materials. Flow in these upper weathered units is controlled by regional dip, local surface and bedrock topography, and lithology. Within these upper weathered sections, paleochannels of coarser material commonly serve as preferential flow paths for groundwater. The unconfined bedrock aquifers are recharged from streams and ponds and the downward movement of groundwater from overlying surficial deposits.

Flow in the unweathered bedrock aquifers of the Arapahoe and Laramie formations and the Fox Hills Sandstone is controlled primarily by regional dip. The lower sandstone unit of the Laramie Formation and the underlying Fox Hills Formation is a regionally important aquifer in the Denver Basin. These units subcrop beneath the Rocky Flats Alluvium west of the industrial complex and can be seen in abandoned quarries near the western edge of the site. The steeply dipping beds of these units quickly flatten to the east. Recharge of the Laramie/Fox Hills aquifer occurs along the limited outcrop and steeply dipping subcrop areas between the site and the outer edge of the Front Range foothills. The fact that the Laramie/Fox Hills aquifer is separated from the upper alluvial and weathered bedrock aquifers by more than 400 feet of low-permeability claystones indicates that little, if any, hydraulic connection exists.

Discharge from the unconfined shallow aquifers occurs as seeps where the water table is intersected by the ground surface, evapotranspiration from deep-rooted plant species (e.g., riparian cottonwoods) in areas with a shallow water table, evaporation for interstitial waters in the capillary zone, and subsurface flow into streams or ponds.

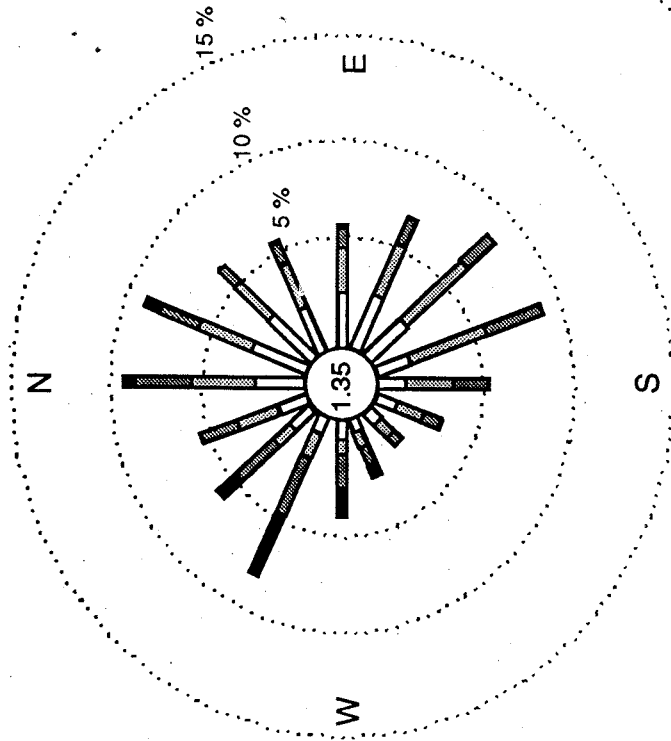
Refer to the Hydrogeologic Characterization Report (EG&G 1995) for a complete description of the hydrogeologic characteristics of the geologic units underlying the site.

2.1.7 Climate

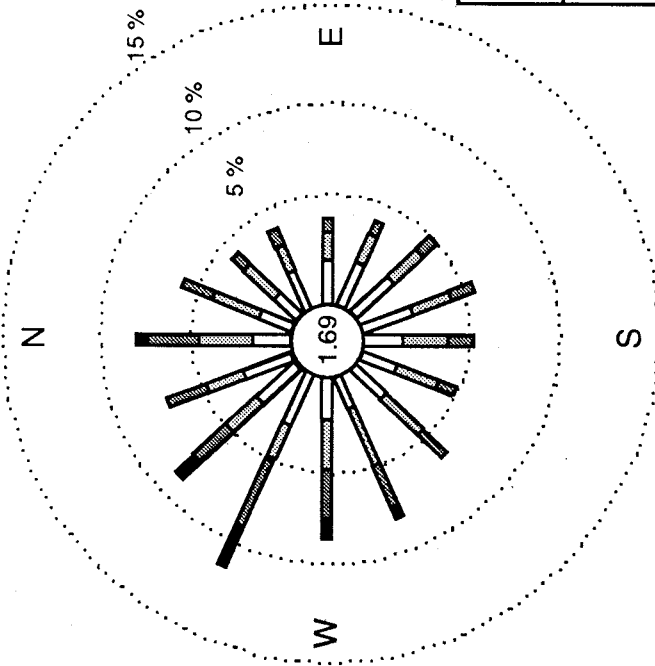
The region has a highly continental, semi-arid climate characteristic of much of the southern Rocky Mountain Front Range. Mean annual precipitation is approximately 15 to 16 inches, based on 20-year means for Boulder and Lakewood, Colorado (NOAA 1992). The wettest season is spring (March through May), which accounts for about 40 percent of the total annual precipitation. This season experiences occasional heavy snowfall events as well as periods of steady rain (C. Dickerman, personal communication, 1995). Precipitation gradually declines through the summer, usually occurring as brief but intense thunderstorms. Summer rainfall during June through August contributes about 30 percent of the annual total. Autumn and winter account for 19 and 11 percent of the total, respectively. Snowfall commonly occurs as early as September and as late as May; the 85-inch mean annual snowfall provides approximately half of the total moisture for the year. Annual free-water (pan) evaporation is approximately 45 inches, which is roughly 2.5 times the annual precipitation. Relative humidities average approximately 46 percent.

Temperatures at RFETS exhibit large diurnal and annual ranges but are generally moderate. Periods of extremely hot or cold weather are usually brief and may not occur every year. Average minimum and maximum temperatures, based on 20-year means (for Boulder and Lakewood, Colorado), are approximately 19°F and 42°F in January and 59°F and 88°F in July (NOAA 1992). Temperatures as low as -25°F and as high as 105°F have been recorded at these monitoring locations. The mean annual temperature is 52.1°F for Boulder and 50.5° for Lakewood.

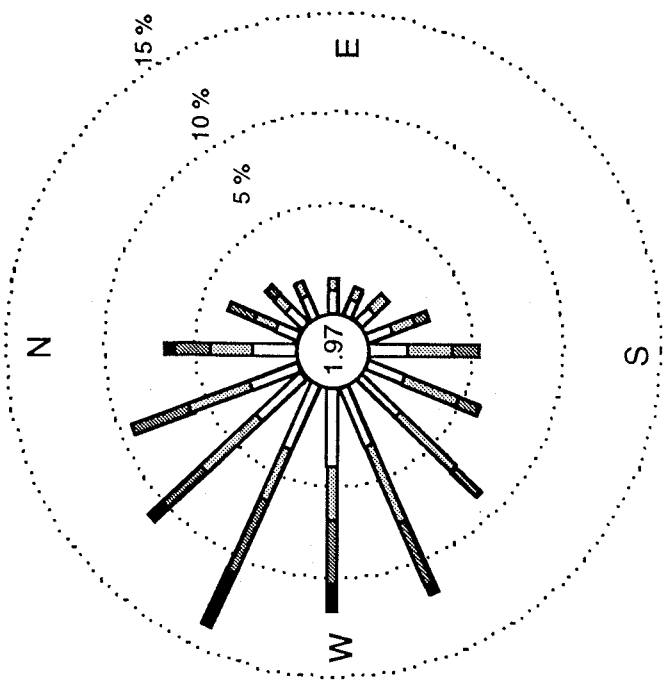
RFETS is noted for its strong winds (Figure 2-7). Gusty winds frequently occur with thunderstorms and the passage of cold fronts. The highest wind speeds are from the west and occur in periods of strong east-west pressure gradients. The strong windstorm season at RFETS extends from late November into April; the height of the season usually occurs in January.



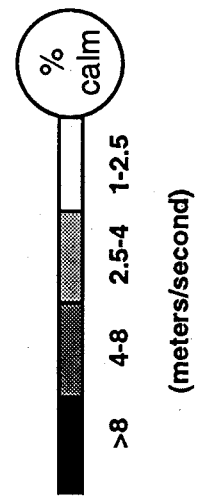
1992 Day



1992 Total



1992 Night



U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

Final Draft
Ecological Risk Assessment Methodology
Technical Memorandum No. 2
Sitewide Conceptual Model

1992 Wind-Rose Diagrams for
Rocky Flats Environmental Technology Site
February 1995

Figure 2-7

Windstorms at RFETS typically last 8 to 16 hours and are very gusty in nature. RFETS experiences wind speeds exceeding 75 miles per hour (mph) in almost every season; gusts exceeding 100 mph are experienced every three to four years. Northwesterly wind directions and wind speeds under 15 mph represent the average conditions at RFETS. Moderate northerly or southerly winds are common year-round, and easterly upslope winds occur when high pressure is centered over the central Rockies. These winds are associated with cyclogenesis east of the Rockies (R. Armstrong, personal communication, 1995).

2.2 Ecology

2.2.1 Overview

RFETS is located just below the elevation at which plains grasslands grade abruptly into lower montane (foothills) forests. The topographic diversity, and associated differences in substrate and microclimate, associated with this transition zone are reflected in a mosaic of plant and animal communities.

The following subsections briefly describe the major plant, wildlife, and aquatic communities at RFETS. A complete species list of vegetation, mammals, birds, reptiles, and fish occurring onsite and in association with the site can be found in SOP 5-21200-OPS-EE (EG&G 1994c). Additional information is provided on the Rock Creek basin, which has been used as an onsite reference area for ecological assessment endpoints at RFETS, and on the Walnut Creek and Woman Creek drainages, which include all of the IHSSs at the site. The following descriptions of the terrestrial and aquatic biota of RFETS are sitewide in context but apply to conditions within the three drainages because they compose the entire site.

2.2.1.1 *Vegetation*

The present vegetation of the site is dominated by a mixed prairie ecosystem. Some areas show the lingering effects of prior grazing, and other areas clearly reflect the prolonged absence of use by domestic livestock. A relatively small percentage of the area outside the industrial complex is disturbed ground associated with various historic or ongoing activities. Most of the upland surfaces and gentle hillsides support a mixture of native grasses, forbs (broadleaf herbaceous species), and subshrubs. Species composition and dominance depend primarily on soil texture and soil moisture.

Relatively mesic (moist) sites compose 77 percent of the total area at RFETS. These sites often support stands of midgrasses and, in particularly moist or undisturbed sites, tallgrasses. Areas of tallgrass prairie are particularly limited in the region because of extensive agriculture or development; small remnant communities are present in xeric piedmont areas in the northwestern corners of the site.

Relatively xeric (dry) sites compose 18 percent of the total area at RFETS. These sites differ from the mesic grasslands primarily in having shorter and sparser cover, occasionally dominated by species typical of shortgrass prairie. Because drier areas are slower to recover from disturbance, some of the xeric sites contain substantial amounts of weedy annual grasses and forbs. Yucca and cacti are conspicuous in areas of historically heavy grazing and on sites with shallow, rocky soils.

Relatively hydric (wet) sites compose 5 percent of the total area at RFETS. These sites support hydrophytic forb and shrub species and are located in wetland areas along north Walnut Creek and Woman Creek.

Major habitat types at RFETS are described below. Habitat summaries are based on descriptions provided in the ecology standard operating procedures (SOPs) for RFETS (EMD Operating Procedures Manual No. 4-K21-ENV-ECOL.11, pending approval). A more quantitative description, including cover and richness data, of several of the habitat types listed below may be found in the EcMP 1994 Annual Report (EG&G 1993b). The distribution of habitat (vegetation) types at the site is shown on Plate 2-3. Occurrences of wetland units as identified by EG&G as of November 22, 1994, are shown on Plate 2-4.

Shortgrass Grassland. This unit consists of upland habitat dominated by native shortgrasses, especially buffalograss (*Buchloe dactyloides*) and blue grama (*Bouteloua gracilis*). Prairie junegrass (*Koeleria pyramidata*), red three-awn (*Aristida purpurea*), cheatgrass (*Bromus tectorum*), small soapweed (*Yucca glauca*), and cacti may be locally abundant, especially on very dry sites. The relatively low species diversity and vegetation height are important influences on use by birds, small mammals, and large mammals. Shortgrass grassland is not extensive at RFETS and appears primarily as small inclusions in other prairie types.

Xeric Mixed Grassland. The term "mixed" refers to the presence of elements from different biomes, including tallgrass, midgrass, and shortgrass prairies. This type is defined as upland habitat dominated by a mixture of native perennial grasses of varying heights, plus perennial forbs, subshrubs, and cacti. It is best developed on narrow ridge tops between drainages.

Bunchgrasses tend to dominate this type. Prevalent native species include prairie junegrass, red three-awn, and mountain muhly (*Muhlenbergia montana*), with varying amounts of blue grama, side-oats grama (*Bouteloua curtipendula*), and sand dropseed (*Sporobolus cryptandrus*). Other common species include needle-and-thread (*Stipa comata*), big bluestem (*Adropogon gerardii*), little bluestem (*A. scoparium*), Canada bluegrass (*Poa compressa*), bottlebrush squirreltail (*Sitanion hystrix*), and narrowleaf sedge (*Carex stenophylla*). Yucca and cacti are locally common in areas of shallow soil. The greater richness and structural complexity of xeric mixed grassland compared to shortgrass grassland generally result in a greater diversity and density of birds and small mammals.

Mesic Mixed Grassland. This is the predominant habitat type at RFETS, occurring both as large communities and small inclusions in other types. It generally occupies moister sites than the preceding type and tends to be dominated by sod-forming (rhizomatous) grasses. Greater soil moisture may reflect a number of factors, such as subirrigation of the coarse alluvial soils, snow accumulation, northerly aspect, protection from desiccating winds, and finer soils. This type occurs on broad ridge tops, hillsides, and valley floors. Western wheatgrass (*Agropyron smithii*) is typically the dominant species. Other prevalent graminoids include blue grama, side-oats grama, prairie junegrass, big bluestem, little bluestem, Canada bluegrass, Kentucky bluegrass (*Poa pratensis*), needle-and-thread, green needlegrass (*Stipa viridula*), sleepygrass (*Stipa robusta*), switchgrass (*Panicum virgatum*), and narrowleaf sedge. Fringed sagebrush (*Artemisia frigida*), prairie sage (*A. ludoviciana*), and broom snakeweed (*Gutierrezia sarothrae*) are common throughout this type. Non-native species such as knapweed (*Centaurea diffusa*), cheatgrass (*Bromus tectorum*), smooth brome (*Bromus inermis*), and Russian thistle (*Salsola iberica*) also exist. The prevalence of taller and more sod-forming grasses, a generally higher diversity of native forbs, and an increased abundance of low shrubs or subshrubs influences the use by small birds and mammals.

Rehabilitated (Reclaimed) Grassland. This type generally occurs as distinct plantings of introduced range or pasture grasses, particularly smooth brome (*Bromopsis inermis*) and intermediate wheatgrass (*A. intermedium*), with minor amounts of crested wheatgrass (*Agropyron cristatum*). Many of the stands are nearly a monoculture of the planted species. The low plant diversity and structure of these coarse grasses are important limiting factors on wildlife use.

Deciduous (Riparian) Woodland. These linear habitats usually consist of mature plains cottonwoods (*Populus deltoides*) and peachleaf willows (*Salix amygdaloides*), occurring either as small clumps or individual trees along some drainages, ponds, and seeps. Associated species often include those listed below for bottomland shrubland, as well as wild rose (*Rosa* spp.),

golden currant (*Ribes aureum*), snowberry (*Symphoricarpos* spp.), and a variety of grasses and forbs. The presence of large trees and seasonal availability of surface water attract wildlife not otherwise associated with the prairie ecosystems that dominate the site.

Bottomland (Riparian) Shrubland. These dense communities occur in persistently moist or wet sites adjacent to streams, ditches, and ponds, often in association with deciduous woodland. Dominant species include coyote willows (*Salix exigua*), peachleaf willows, and leadplant (*Amorpha fruticosa*). The shrubby species that dominate this type support use by some wetland or riparian wildlife species, but diversity and density are typically lower.

Wet Meadow. This herbaceous habitat occupies areas intermediate in soil moisture between mesic mixed grassland and short marsh (see below) and contains elements of both. Prominent species may include Kentucky bluegrass, smooth brome, prairie cordgrass (*Spartina pectinata*), and switchgrass, as well as sedges (*Carex* spp.), rushes (*Juncus* spp.), and a variety of mesophytic forbs. Wet meadow may occur as an ecotone (transition) between drier and wetter habitats or as distinct stands. This and the remaining habitat types are much less extensive than those described above.

Short Marsh. Seasonally wet (saturated) sites such as hillside seeps are often dominated by sedges, rushes, and hydrophytic forbs. Low plant height, low plant species diversity, dense cover, and wet soil limit the variety of wildlife using this habitat type.

Tall Marsh. The presence of taller wetland species usually indicates a more persistent saturation or inundation than short marsh. Tall marsh typically occurs on valley floors and along drainages or ditches. It is dominated by broadleaf and narrowleaf cattails (*Typha latifolia* and *T. angustifolia*) or bulrushes (*Scirpus* spp.) and occasional hydrophytic forbs. Low plant species diversity and wet soil limit burrowing opportunities by small mammals, but sizable stands may attract species not otherwise found in the prairie ecosystems that dominate the site.

Tall Upland Shrubland. Mixtures of tall shrubs occur as scattered thickets in mesic but somewhat well-drained sites, such as north-facing slopes, valley floors, and shallow depressions. It is typically dominated by hawthorn (*Crataegus erythropoda*), chokecherry (*Prunus virginiana*), and wild plum (*P. americana*). Structural diversity, dense cover, and abundant rosaceous fruits may support wildlife not otherwise found in the prairie ecosystems of the site.

Short Upland Shrubland. Shorter shrub species occur in low spots or stream banks between more mesic riparian habitats. This type is typically dominated by skunkbrush sumac (*Rhus*

trilobata) and mountain ninebark (*Physocarpus monogynus*)—two species normally associated with the lower foothills—as well as snowberry. Cover and structural diversity may attract wildlife not otherwise in the prairie ecosystems of the site.

Ponderosa Pine Woodland. Scattered pines generally occur on rocky uplands, especially with shallow sandstone such as in the northwestern portion of the site at the western edge of Woman Creek and on the eastern side of the site along the Rock Creek escarpment. The understory beneath the open pine canopy is typically dominated by native species characteristic of the foothills a few miles west of the site. Shrubs in the understory include wax currant (*Ribes cereum*), skunkbrush, and snowberry. The ponderosa pine attract wildlife not otherwise present in prairie ecosystems, including a number of species that are eastward extensions of the nearby foothills fauna.

Annual Grass/Forbs. Weedy species dominate many of the disturbed areas at RFETS. Prevalent species are usually aggressive, non-native annual or biennial plants. Weedy mustards, weedy composites, field bindweed (*Convolvulus arvensis*), and great mullein (*Verbascum thapsus*) often dominate these areas, along with cheatgrass and Japanese brome (*Bromus japonicus*). Cover, height, and seed production may support some wildlife use, but relatively low diversity, extreme seasonality, and short-lived productivity are limiting factors.

Disturbed/Barren Lands. This category includes areas essentially devoid of vegetation as a result of prolonged, frequent, or recent disturbance. The lack of cover and food limit wildlife use.

2.2.1.2 Wildlife

As in most of the Front Range Urban Corridor, the wildlife of RFETS has been greatly influenced by the increase in human use and disturbance over the past 100 years. Most notable have been reductions in the number and diversity of ungulates (hoofed animals) and large predators. However, the habitat diversity of RFETS, coupled with protection from grazing and human disturbance across most of the site, have resulted in a relatively rich and intact animal community. Species that typify the various groups of terrestrial vertebrates and invertebrates at RFETS are summarized below. Annual monitoring of the site by EG&G as part of the Natural Resource Protection and Compliance Program (NRPCP) and EcMP provide additional information on species occurrence, relative abundance, and habitat use (DOE 1993a, EG&G 1993b).

Large Mammals. The most abundant and conspicuous large mammal at the site is the mule deer (*Odocoileus hemionus*). This large, wide-ranging species occurs throughout the site but is most frequently observed in the three stream valleys, where the presence of thermal and hiding cover, abundant browse, and water provide good habitat. The population of mule deer is estimated at around 150. A small number of white-tailed deer (*O. virginianus*) have also been observed onsite.

Large or medium-sized mammalian predators include the coyote (*Canis latrans*), which is common and widespread, and the red fox (*Vulpes vulpes*), which is uncommon. Other carnivores documented onsite include the badger (*Taxidea taxus*), long-tailed weasel (*Mustela frenata*), raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*). Feral house cats (*Felis domesticus*) also occur onsite. Two additional predators, the gray fox (*Urocyon cinereoargenteus*) and bobcat (*Lynx rufus*), have been documented during annual wildlife monitoring (DOE 1993a).

The black bear (*Ursus americanus*), a large omnivore, has not been observed at RFETS. However, a sow and two cubs were seen not far from the site in Superior, Colorado.

Another large species, the mountain lion (*Felis concolor*), also has not been observed at RFETS but has become increasingly common along the western edge of nearby cities such as Boulder and Golden. The abundance of deer at the site would serve to attract this predator.

Small Mammals. Live-trapping programs conducted at the site during the past two decades (DOE 1980, 1992a) have indicated that the mosaic of native communities at RFETS supports a relatively rich small mammal fauna. The most widespread rodent onsite is the deer mouse (*Peromyscus maniculatus*), which has been captured in nearly every habitat type. This species represented 72 percent of total small mammal captures during the EcMP in 1993 (EG&G 1993b). The second most common species, the meadow vole (*Microtus pennsylvanicus*), was found primarily in riparian and reclaimed communities and represented only 9.5 percent of the total captures during 1993 (EG&G 1993b). Other small mammals captured include the prairie vole (*Microtus ochrogaster*), plains harvest mouse (*Reithrodontomys montanus*), western harvest mouse (*R. megalotus*), and hispid pocket mouse (*Chaetodipus hispidus*).

Less widely distributed species include the silky pocket mouse (*Perognathus flavus*), plains pocket mouse (*P. flavescens*), olive-backed pocket mouse (*P. fasciatus*), and meadow jumping mouse (*Zapus hudsonius*). The pocket mice are restricted to xeric grassland or shortgrass communities, and the two jumping mice generally prefer lush, more mesic sites. The meadow

jumping mouse is of special concern because the subspecies that occurs at RFETS and elsewhere in the region, Preble's meadow jumping mouse (*Z. h. preblei*), is a candidate for federal listing as threatened or endangered (Section 2.2.5). Quantitative descriptions of Preble's meadow jumping mouse distribution and abundance can be found in the EcMP 1995 Annual Report (EG&G, forthcoming).

A variety of other rodents has been documented at the site. This variety includes the house mouse (*Mus musculus*) near buildings, Mexican woodrat (*Neotoma mexicana*) in rocky sites, and muskrat (*Ondatra zibethicus*) in ponds, as well as the porcupine (*Erethizon dorsatum*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), small colonies of black-tailed prairie dogs (*Cynomys ludovicianus*), and a few fox squirrels (*Sciurus niger*).

Two shrew species have been documented during live-trapping programs: the water shrew (*Sorex palustris*) around ponds and the Merriam's shrew (*S. merriami*). Three lagomorphs have also been observed.

By far, the most abundant lagomorph is the desert cottontail (*Sylvilagus audubonii*), which is common in shrubby or rocky sites as well as disturbed areas and around buildings. Other species present on the site are the black-tailed jackrabbit (*Lepus californicus*) and the white-tailed jackrabbit (*L. townsendii*).

Raptors. A variety of birds of prey occur at RFETS. The most common species are the red-tailed hawk (*Buteo jamaicensis*) and great horned owl (*Bubo virginianus*), both of which are present on the site throughout the year and nest in mature cottonwoods or conifers across the site. Other species that breed onsite include the Swainson's hawk (*Buteo swainsonii*), American kestrel (*Falco sparverius*), and long-eared owl (*Asio otus*). All of these raptors are common in open areas with scattered trees, such as typifies the site.

Species that have been observed during the breeding season but not documented to nest onsite include the northern harrier (*Circus cyaneus*), Cooper's hawk (*Accipiter cooperii*), and sharp-shinned hawk (*A. striatus*). The rough-legged hawk (*Buteo lagopus*) is common during the winter. The ferruginous hawk (*Buteo regalis*) is a candidate for federal listing and is occasionally seen during the nesting season but is more common during the winter.

Wide-ranging raptors that have been observed at RFETS include the turkey vulture (*Cathartes aura*), golden eagle (*Aquila chrysaetos*), bald eagle (*Haliaeetus leucocephalus*), prairie falcon (*Falco mexicanus*), and peregrine falcon (*F. peregrinus*). The bald eagle and peregrine falcon

are of particular concern because of their status as federally listed threatened or endangered species (Section 2.2.5).

It is likely that all of these raptors are attracted to the site by the presence of suitable perching or nesting sites, the abundance of prey, and the relative lack of disturbance.

Water Birds. The artificial ponds constructed at RFETS for control of surface water runoff, and earlier for agricultural purposes, support seasonal use by a number of wading birds, shorebirds, waterfowl, and related species. The largest water bird observed at the site is the great blue heron (*Ardea herodias*), which preys on fish, amphibians, and large macroinvertebrates. Herons have been seen at most of the ponds at RFETS but are more prevalent at Pond C-2 because of its abundant fathead minnow population. The smaller black-crowned night-heron (*Nycticorax nycticorax*) also feeds along the ponds, although less commonly. Neither of these species is known to nest onsite, although they use the site during the breeding season. Two other water birds that occur during the breeding season but are not documented to nest at RFETS are the pied-billed grebe (*Podilymbus podiceps*) and double-crested cormorant (*Phalacrocorax auritus*). Both of these fish-eating species are most commonly seen on the larger ponds such as A-3, A-4, and B-5.

Waterfowl frequently seen on the ponds include the Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), gadwall (*A. strepera*), green-winged teal (*A. crecca*), and blue-winged teal (*A. discors*). All of the species listed above nest in wetland vegetation along the margins of the ponds. A large number of other waterfowl also occur onsite, especially during the spring and fall migrations. Representative species seen during these seasons include the American widgeon (*Anas americana*), northern shoveler (*A. clypeata*), common merganser (*Mergus merganser*), bufflehead (*Bucephala albeola*), common goldeneye (*B. clangula*), redhead (*Aythya americana*), and greater and lesser scaups (*A. marila*, *A. affinis*) (DOE 1993a).

Shorebirds documented to use the shallow waters and mudflats adjacent to the ponds at RFETS include the spotted sandpiper (*Actitis macularia*), pectoral sandpiper (*Calidris melanotos*), solitary sandpiper (*Tringa solitaria*), and willet (*Catoptrophorus semipalmatus*). These sandpipers appear to be limited to seasonal use of the site for resting and feeding on aquatic prey during spring and fall migrations. The killdeer (*Charadrius vociferus*) is known to nest onsite. This insectivorous species is not restricted to shoreline habitats, instead preferring short, sparse cover such as along roadsides or other disturbed sites.

Two other species that occur at RFETS and are appropriately included with the water birds are the sora (*Porzana carolina*) and American coot (*Fulica americana*). These species are known to nest onsite in cattails and other rank vegetation along pond margins.

Small Birds. Communities of small birds at RFETS reflect the variety of habitat types present. The most extensive communities on the site are dominated by ground-nesting species typical of prairie ecosystems in the region. These species include the western meadowlark (*Sturnella neglecta*), vesper sparrow (*Pooecetes gramineus*), and grasshopper sparrow (*Ammodramus savannarum*), plus the horned lark (*Eremophila alpestris*) in more xeric habitats.

The presence of mature deciduous trees along riparian corridors or as scattered individuals in moist sites attract arboreal (tree-nesting) species such as the northern flicker (*Colaptes auratus*), eastern and western kingbirds (*Tyrannus tyrannus* and *T. verticalis*), black-billed magpie (*Pica pica*), American robin (*Turdus migratorius*), warbling vireo (*Vireo gilvus*), yellow warbler (*Dendroica petechia*), northern oriole (*Icterus galbula*), blue grosbeak (*Guiraca cyanea*), and American and lesser goldfinches (*Carduelis tristis* and *C. psaltria*).

Wetland shrubs and cattails support a songbird community dominated by the red-winged blackbird (*Agelaius phoeniceus*) or, less commonly, the yellow-headed blackbird (*Xanthocephalus xanthocephalus*), as well as the common yellowthroat (*Geothlypis trichas*) and song sparrow (*Melospiza melodia*).

Wooded draws with tall shrubs, such as in the Rock Creek drainage, attract foothills species such as the yellow-breasted chat (*Icteria virens*), MacGillivray's warbler (*Oporornis tolmiei*), black-headed grosbeak (*Pheucticus melanocephalus*), lazuli bunting (*Passerina amoena*), and green-tailed and rufous-sided towhees (*Pipilo chlorura* and *P. erythrophthalmus*).

Other common small birds at RFETS include the common nighthawk (*Chordeiles minor*) across the site; belted kingfisher (*Ceryle alcyon*) along riparian corridors and ponds; Say's phoebe (*Sayornis saya*) around buildings; barn swallow and cliff swallow (*Hirundo rustica* and *H. pyrrhonota*) around buildings and culverts; and European starling (*Sturnus vulgaris*), house finch (*Carpodacus mexicanus*), and house sparrow (*Passer domesticus*) around buildings and shade trees. House finches were occasionally abundant in native or disturbed communities adjacent to the industrial complex; this species apparently found the weeds in some of these areas to be a major source of seeds and/or insect prey. Brown-headed cowbirds (*Molothrus ater*) were also common at the site, especially around trees. This species is a nest parasite that lays its eggs in the nests of other species, which then raise its young at the expense of their own progeny.

All of the species listed above are known to nest at the site. During the winter, most of these species are not present. Typical winter birds at RFETS include resident species such as the flicker, magpie, starling, house finch, and house sparrow, as well as winter visitors such as the tree sparrow (*Spizella arborea*), white-crowned sparrow (*Zonotrichia leucophrys*), and dark-eyed junco (*Junco hyemalis*)—all in wooded or shrubby sites—as well as large flocks of horned larks and, less abundantly, western meadowlarks.

Reptiles. As is typical for the region, reptiles (and amphibians; see below) are not well represented at RFETS. The most common species are the bullsnake (*Pituophis melanoleucus*), yellow-bellied racer (*Coluber constrictor*), garter snakes (*Thamnophis* spp.), and prairie rattlesnake (*Crotalus viridis*). All of these species occur in the open grassland habitats that dominate the site, although the garter snakes are frequently found near (or even in) water.

Additional reptiles observed, and their preferred habitats, include the short-horned lizard (*Phrynosoma douglassii*) in open grasslands, eastern fence lizard (*Sceloporus undulatus*) in rocky shrublands such as along the Rock Creek drainage, and western painted turtle (*Pseudemys picta*) in ponds, particularly Lindsay Pond along Rock Creek.

Amphibians. By far the most abundant and widespread amphibian at RFETS is the boreal chorus frog (*Pseudacris triseriata*). This small, wetland-dwelling member of the tree-frog family occurs in virtually every stream, pond, ditch, or other areas where surface water persists through the spring and early summer. A true frog, the northern leopard frog (*Rana pipiens*) is completely aquatic and requires permanent water such as is found in some of the ponds onsite.

The Woodhouse's toad (*Bufo woodhousei*) breeds in ponds and streams at the site but may wander considerable distances from water in search of insect prey. The plains spadefoot (*Scaphiopus bombifrons*) requires the least persistent water of any of the amphibians at the site; like true toads such as the Woodhouse's toad, spadefoots spend most of the year in the mud beneath seasonally wet sites.

Another common amphibian at the site is the tiger salamander (*Ambystoma tigrinum*). The aquatic larvae of this species, which some people erroneously refer to as "mudpuppies" or "water dogs" (these names are reserved for an aquatic species of the southeastern United States) have been documented in several of the ponds. During late summer, the black-and-yellow-striped adults may move considerable distances across land, holing up in animal burrows during the day to avoid desiccation.

Terrestrial Arthropods. Four classes of arthropods have been captured during sweep-netting, pitfall-trapping, or opportunistic netting of invertebrates at RFETS: the millipedes (Diplopoda), isopods or pill bugs (Crustacea), spiders and allies (Arachnida), and insects (Insecta). Of these, the insects were the most abundant and taxonomically diverse group.

Insects captured during site surveys have included representatives of nine major families. In general, leafhoppers (Homoptera: Cicadellidae) are the most abundant insects. Other primarily herbivorous groups include treehoppers (Homoptera: Membracidae), spittle bugs (Homoptera: Cercopidae), grasshoppers (Orthoptera: Acrididae), seed bugs (Hemiptera: Lygaeidae), leaf bugs (Hemiptera: Miridae), and leaf beetles (Coleoptera: Chrysomelidae). Other common groups include predatory ladybird beetles (Coleoptera: Coccinellidae) and omnivorous ants (Hymenoptera: Formicidae).

Although not as diverse as the insects, true spiders (Hydracarina: Araneae) were the second most abundant group overall in terms of numbers of captures. Spiders are predatory.

The arthropods listed above provide a prey base for insectivores. However, grasshoppers and leafhoppers are probably the most important prey groups because of their abundance, size, and tendency to occur on the foliage of plants, where they are easily detected and captured. Large grasshoppers are also consumed by predators such as kestrels and coyotes.

2.2.1.3 Aquatic Organisms

As noted previously, the retention ponds, old agricultural ponds, natural drainages, and ditches at RFETS provide a limited variety of aquatic habitat. Although these habitats are limited in both variety and areal extent, they tend to serve as potentially important exposure pathways to ecological receptors. This results from the fact that (1) surface water and shallow groundwater are important transport mechanisms at RFETS, (2) exposure to aquatic organisms is often intensified by prolonged contact and direct uptake from the surrounding medium (water) as well as trophic uptake, and (3) water is a limited resource in prairie ecosystems and thus tends to receive concentrated use.

As noted in the 1993 EcMP Report (EG&G 1993b), the hydrology and habitat quality of streams and ponds at the site are highly regulated by onsite activities and the needs of offsite ranchers. Thus, both stream flow and pond levels fluctuate in response to these anthropogenic factors as well as to seasonal variations in precipitation and infiltration.

The tendency of many of the ponds, and most stream reaches, to periodically become completely dry makes these habitats unsuitable for aquatic organisms that require permanent water. Even organisms adapted to seasonally dry sites may be precluded by the unpredictability of water quantity relative to specific life cycles. In ponds that do not become completely dry, the fluctuations in levels inhibit the establishment of a productive littoral (near-shore) zone.

The following subsections summarize the prevalent aquatic macroinvertebrate and vertebrate communities at the site. EG&G maintains an onsite reference collection of aquatic biota, including benthic macroinvertebrates, emergent insects, zooplankton, and phytoplankton.

Macroinvertebrates. Across most of the site, stream communities are strongly influenced by low and nonpersistent flows, except for a few isolated pools, and by the predominantly fine-textured substrate. The most abundant and widespread groups overall in lotic (stream) communities are the larvae of true flies (Diptera) and mayflies (Ephemeroptera). The most common dipteran taxa are blackflies (Simuliidae) and midges (Chironomidae). Both caenid and baetid mayflies are also common. Other aquatic invertebrates include caddisflies (Trichoptera), craneflies (Diptera: Tipulidae), predatory damselfly larvae (Odonata), and two non-insect taxa, the amphipod (sideswimmer) *Hyaella azteca* and the snail *Physella* sp.

Pond (lentic) habitats provide a more reliable water source than the intermittent or ephemeral stream channels, but the fine substrate and, in many ponds, relative lack of aquatic plants limit the macroinvertebrate communities. Most of the communities are strongly dominated by midges and aquatic earthworms (Oligochaeta). Ponds with a well-developed aquatic plant community along the edges support a more diverse assemblage of nektonic forms, including water striders (Hemiptera: Gerridae) and water boatmen (Hemiptera: Corixidae). Predatory dragonfly nymphs (Odonata) are present in some of the ponds, as are crayfish (Astacidae). Crayfish are the largest aquatic invertebrates at the site and, because of their size, are a potentially important prey for some predators such as largemouth bass, herons, and raccoons.

Fish. As with macroinvertebrates (see above), low and intermittent flows along most stream reaches within RFETS greatly limit the ichthyofauna of the site. Species captured in the streams include the creek chub (*Semotilus atromaculatus*), stoneroller (*Campostoma anomalum*), fathead minnow (*Pimephales promelas*), and green sunfish (*Lepomis cyanellus*). Of these species, the creek chub is the most tolerant of poor water conditions. McClane (1978) reported that, within its range, "the creek chub may be found in almost any stream capable of supporting fish life." This species feeds on a variety of small invertebrate prey, while the fathead minnow feeds

mostly on plankton and the stoneroller consumes both plant and invertebrate prey. Green sunfish feed on nektonic invertebrates as well as smaller fishes.

Fish communities in onsite ponds are highly influenced by the presence of suitable substrates, aquatic vegetation, and persistence of water. Species present include the four species listed above, plus the golden shiner (*Notemigonus crysoleucus*), white sucker (*Catostomus commersoni*), and largemouth bass (*Micropterus salmoides*). Golden shiners feed on a variety of small prey and algae and may themselves be important prey for larger fish or piscivorous birds because of the large populations they attain and their relatively large size. White suckers are "tolerant of large amounts of pollution, siltation, and turbidity and...able to survive in waters low in oxygen" (McClane 1978). This widespread species feeds on insect larvae and algae. Largemouth bass caught in some of the ponds include large individuals that undoubtedly are at the top of the aquatic food web, aside from large terrestrial piscivores such as cormorants or great blue herons.

2.2.2 Rock Creek

The Rock Creek basin was selected as the onsite reference area primarily because it is outside the influence of historic production, storage, and disposal activities at the site and contains no IHSSs. For this reason, Rock Creek is a good reference area for measurement endpoints addressing chemical loading in plant and animal tissues and direct chemical effects. In general, the Rock Creek basin is much more similar to the Walnut Creek and Woman Creek basins than it is different, and it is much more similar to these basins than offsite areas that were considered. The major difference between onsite and offsite conditions, as they relate to the issue of reference areas, is the extended isolation from grazing by livestock, intensive human activity, and physical disturbance in most of the onsite area outside the industrial complex. Differences related to land use would be expected to confound, if not completely mask, ecological effects in the Woman and Walnut Creek valleys in comparison with offsite areas.

Rock Creek is not a perfect reference area for measurement endpoints involving community factors such as species composition and structure because of ecological differences related to topography and, to a lesser extent, historic use. The major topographic difference is the fact that the Rock Creek valley is deeper than the other drainages onsite and flows generally northeast rather than east. As a result of greater shading and some mesic conditions on its sideslopes, the Rock Creek valley supports much better developed upland shrub communities on the sideslopes and a more mesic valley floor. Another difference is that the xeric grasslands on the northeast-trending divides appear to have been less heavily grazed and subject to less

physical disturbance. Nonetheless, as noted above, Rock Creek is much more similar to Woman and Walnut creeks than other drainages in the vicinity—again, because of more recent or continued ranching of offsite areas.

The remainder of this section briefly describes some ways in which the Rock Creek drainage differs from the general site overview provided in Section 2.2.1. Subsequent sections describe important ways in which the Woman and Walnut Creek drainages are similar to, and different from, both Rock Creek and the overall site.

The deeply dissected uplands that characterize the Rock Creek drainage reflect the more rapid downcutting associated with its being a tributary of a large perennial stream (Coal Creek). As described above, steeper slopes and greater relief of the Rock Creek basin, coupled with a more northeasterly orientation, results in generally more mesic conditions on valley sideslopes and the valley floor. This condition, in combination with the lesser amount of historic grazing and other disturbance, results in an overall perception, that the Rock Creek basin is more “natural” than the other two basins. This perception, while not completely true based on quantitative community data, underscores the high value placed on visual diversity.

As shown on Table 2-3, Rock Creek is the smallest of the three drainage basins that cross RFETS. Despite its smaller areal extent, this basin has the greatest community diversity (in terms of native habitats contributing more than 1 percent or more of the total). The greater proportion of xeric mixed grassland (43 percent) than elsewhere onsite is related to the fact that drainage divides are broader but is somewhat misleading because of the generally better habitat quality. Values for xeric and mesic mixed grassland combined, however, are very similar among drainages, as are those for tall and short marshland. These data underscore the overall similarity of the three areas.

Other significant points indicated by the data in Table 2-3 are that (1) riparian woodland is less extensive, being limited to a few isolated cottonwoods that do, however, support nesting by raptors; (2) reclaimed grassland is lacking because the area was never cultivated and was subject to minimal RFETS-related disturbance; and (3) substantial areas of tall upland shrubs, short upland shrubs, and ponderosa pine are essentially limited to this basin. As a result of these differences, riparian species are much less common along Rock Creek, while foothills shrubland and coniferous forest species are much more common (and, in most cases, found only here). It should be noted that the area of land shown as “disturbed” on the table (10 percent) comprises the DOE “wind site” (a component of the National Renewable Energy Laboratory in Golden) and quarries west of the site and therefore is not related to RFETS activities.

Table 2-3
Percent Coverage of Vegetation Types Within Drainage Basins at RFETS

	Rock Creek	Walnut Creek	Woman Creek
Xeric Mixed Grassland	43	6	14
Mesic Mixed Grassland	37	60	57
Short Grassland	< 1	3	< 1
Reclaimed Grassland	< 1	6	17
Disturbed Land	10	20	5
Tall Marsh	< 1	< 1	1
Short Marsh	4	2	3
Riparian Woodland	< 1	1	1
Riparian Shrub	1	< 1	1
Tall Upland Shrubland	2	0	< 1
Short Upland Shrubland	1	< 1	< 1
Ponderosa Pine Woodland	< 1	0	< 1
Other	< 1	< 1	< 1
Total Area (acres)	1,554	2,414	2,522

Source: EG&G 1992a

With regard to the stream itself, flows in Rock Creek are similar to the other basins. However, Rock Creek differs significantly in that only one pond has been built. This feature, called Lindsay Pond, is an old farm pond that supports a variety of rooted and floating aquatic plants and thus provides habitat for species that cannot tolerate unvegetated ponds. However, the relative lack of ponds on this creek limits use by water birds, amphibians, and other species attracted to pond environments.

Occurrences in the Rock Creek basin by species of special concern (i.e., species afforded special legal status under the Endangered Species Act or candidates for such status) are discussed in Section 2.2.5.

2.2.3 Walnut Creek

The Walnut Creek drainage includes three basin segments: undissected uplands west of the industrial complex, relatively deep valleys separated by narrow ridges in the central portion, and a broad area of low relief beyond the limits of the high terrace. Walnut Creek also has been the most significantly altered drainage; this basin contains several water diversion systems, a total of nine ponds on the North and South Walnut Creek branches, and the landfill pond on the No

Name Gulch tributary. This basin has also been highly modified by extensive areas of fill used in constructing the industrial complex, as well as the present landfill (OU7). Moreover, Walnut Creek contains the vast majority of production, storage, disposal sites, and spill sites at RFETS and by far the greatest percent of area in disturbed land (Table 2-3).

Despite these significant—and frequently adverse—influences, the Walnut Creek basin supports substantial wildlife use. The major ways in which this drainage suffers in comparison to Rock Creek (Table 2-3) are the absence of species associated with ponderosa pine and foothills shrub communities and the greater extent of disturbed land. Marsh communities are more extensive along Walnut Creek, owing to the numerous ponds they surround. The ponds, in turn, make this drainage the most important in terms of water birds and aquatic organisms. Riparian communities also are slightly more extensive along Walnut Creek than Rock Creek.

This basin also contains the highest percentage of mesic mixed grassland and the lowest of xeric mixed grassland. The mesic grassland areas generally support more diverse and abundant plant and animal species (Section 2.2.1). Use of this basin by protected species is summarized in Section 2.2.5

2.2.4 Woman Creek

This drainage differs from the other two basins at RFETS in that the main channel almost completely traverses the site from west to east. Contributions to surface flow from Rocky Flats Lake and diversion ditches, seeps, and inflow from the 881 Hillside (OU1) have resulted in the most continuous and best developed riparian woodland community onsite. The Woman Creek riparian woodland supports a much richer and more abundant community of arboreal songbirds than the other drainages. The dense cover is also heavily used by deer, and the long, unbroken stream course provides a potentially important movement corridor for a variety of species.

Although only two ponds have been constructed on Woman Creek as part of the runoff and pollution control programs at RFETS, both of these ponds, C-1 and C-2, support wildlife use. Pond C-1 is, aside from Lindsay Pond on Rock Creek, probably the most “natural” pond in terms of associated vegetation and persistent water levels. During surveys, the pond was found to contain a few large bass as well as a rich community of smaller fishes. Great blue herons, black-crowned night-herons, and waterfowl also use this pond for resting and feeding. Pond C-2, while far from natural in appearance, supports a very large population of fathead minnows owing to the absence of predatory fishes. The abundance of this small minnow results in heavy use of Pond C-2 by piscivorous birds, particularly herons.

As seen on Table 2-3, Woman Creek contains the largest amount of reclaimed grassland (14 percent). This reflects the fact that much of the southeastern portion of RFETS was historically used for production of small-grain crops or hay. The areas were planted primarily with a monoculture of smooth brome, although areas of crested and intermediate wheatgrasses also occur. Although these reclaimed habitats have a low plant species diversity, and thus do not support the same type or amount of use as richer native grasslands, they nonetheless are productive for some small rodents (particularly harvest mice). Consequently, the reclaimed grasslands were used to some extent by predators such as coyotes and raptors. Use of the Woman Creek basin by protected species is summarized below.

2.2.5 Protected Species

A variety of protected species have been documented at RFETS, and additional protected species are potentially present based on the presence of suitable habitat. As used in this report, protected species include plants or animals that are federally listed as threatened or endangered, candidates for listing as threatened or endangered, or Colorado species of special concern (USFWS 1994a,b; CDOW 1994). RFETS Buffer Zone is an island of relatively undisturbed habitat within a region where most native lands have been heavily grazed, cultivated, developed, or subjected to other ongoing impacts associated with intensive human activity. The following protected species are present or potentially occur within the RFETS vicinity:

Federally Listed Endangered Species

- Bald eagle (State Listed Threatened)
- Peregrine falcon (State Listed Threatened)
- Black-footed ferret

Federally Listed Threatened Species

- Ute ladies'-tresses

Category 1 Candidate for Federal Listing

- Colorado butterfly plant

Category 2 Candidates for Federal Listing

- | | |
|---------------------------------|---------------------|
| • Preble's meadow jumping mouse | • White-faced ibis |
| • Ferruginous hawk | • Mountain plover |
| • Northern goshawk | • Swift fox |
| • Baird's sparrow | • Loggerhead shrike |

Category 3 (no longer a candidate for federal listing)

- Long-billed curlew

Colorado Species of Special Concern

- American white pelican
- Burrowing owl
- Forktip three-awn
- Toothcup

Two federally listed endangered bird species have been observed at RFETS: the bald eagle and peregrine falcon. Bald eagles are increasingly common in the region and occur primarily as migrants or winter residents. To date, use of the site by bald eagles has been limited to overflights and occasional perching by birds probably associated with the reservoirs east of the site. Bald eagles have nested successfully at Barr Lake near Brighton, Colorado, several miles east of the site. A pair of eagles reportedly attempted unsuccessfully to nest at Standley Lake in 1992, 1993, and 1994. Bald eagles feed on fish and waterfowl when streams or ponds are unfrozen. During the winter, this opportunistic species feeds on lagomorphs, carrion, or prey "stolen" from other predators such as the ferruginous hawk (this behavior is referred to as "kleptoparasitism").

Peregrine falcons have nested on rock formations southwest of Boulder during several recent years. This nesting area is only a few miles from the site, and it therefore is not surprising that adult and immature birds have been observed hunting at RFETS. Waterfowl are the preferred prey of peregrine falcons. Peregrine falcons also migrate through the area. During 1994, peregrines were seen onsite in spring, early summer, and fall more commonly than in previous years.

The only federally listed mammal species potentially present at the site is the black-footed ferret (*Mustela nigripes*). This species feeds almost exclusively on prairie dogs, and its range is therefore highly limited by the presence of extensive prairie dog colonies. Although prairie dogs occur at RFETS, the size of the colony is probably not sufficient to support a ferret. Moreover, ferrets have not been observed in association with much more extensive colonies in the region (Fitzgerald *et al.*, forthcoming).

One federally listed threatened plant species, the Ute ladies'-tresses (*Spiranthes diluvialis*), has been found in large numbers on City of Boulder Open Space north of the site and near Clear Creek to the south (EG&G 1991c). Although apparently suitable habitat occurs onsite, Ute

ladies'-tresses have not been found during intensive surveys performed in 1992, 1993, and 1994. The most suitable habitat occurs along sections of Smart Ditch (actually an ephemeral stream valley that is part of the Woman Creek basin; see Section 2.1.5), at Antelope Springs (adjacent to Woman Creek), and at seeps and springs along the Rock Creek valley (EG&G 1993c). Areas surveyed at RFETS are shown on Plate 2-5.

The Colorado butterfly plant (*Gaura neomexicana* ssp. *coloradensis*), a Category 1 species, is also undocumented, but suitable habitat (e.g., wetlands along creeks) is present (EG&G 1993c). Category 1 candidates for federal listing are those species for which there is sufficient information to support proposals to list them as threatened or endangered. However, proposed rules have not yet been issued because this action is precluded at present by other listing activity (USFWS 1994b).

Several species that are classified by the U.S. Fish and Wildlife Service (USFWS) as Category 2 candidates for federal listing have been documented at RFETS. Category 2 candidates are those species that may be appropriate for proposal to listing as threatened or endangered, but supporting data is not currently available (USFWS 1994b).

Preble's meadow jumping mice have been captured in all three drainage basins, including Smart Ditch, during intensive live-trapping programs in 1992, 1993, and 1994 (EG&G 1992b, 1993d). Plate 2-6 shows the capture locations of Preble's meadow jumping mice, along with apparently suitable habitat onsite. Animals were captured in riparian areas with well-developed shrub canopies and a relatively lush understory of grasses and forbs. This is typical of habitats occupied by the subspecies throughout its range.

The ferruginous hawk, also a Category 2 species, was observed in 1990 and 1991 as a summer vagrant. This species may nest near the site and use the open terrain for hunting, primarily for small mammals. Another Category 2 species, the northern goshawk (*Accipiter gentilis*), was reported onsite on one occasion and probably was a vagrant. This species occurs as a fairly common year-round resident in coniferous forests, such as occur in the Front Range a few miles west of the site. Goshawks feed primarily on small birds. The limited number of ponderosa pines onsite is probably not sufficient to support regular use. A third Category 2 bird species observed at the site is Baird's sparrow (*Ammodramus bairdii*). This grassland songbird probably occurs as an irregular migrant. A small number of Baird's sparrows would be expected to use the site for resting and feeding (on seeds and insect prey) during their migration.

Other Category 2 species potentially present at RFETS, based on geographic range and habitat preference, include the white-faced ibis (*Plegadis chihi*), mountain plover (*Charadrius montanus*), and swift fox (*Vulpes velox*). None of these species has been documented onsite.

The loggerhead shrike (*Lanius ludovicianus*), a predatory songbird, has been observed at RFETS on several occasions. Because it has been observed onsite during the breeding season, this species may nest at RFETS. Shrikes are fairly common in western Colorado but are reportedly uncommon to rare in eastern prairie habitats. The subspecies *L. l. migratorius* has undergone a regional decline in the Great Plains and is listed as a Category 2 candidate by USFWS (1994b). Colorado is not within the reported historical range of this subspecies.

The long-billed curlew (*Numenius americanus*), a Category 3 species, was observed on the Walnut Creek/Rock Creek divide in 1993 and in the Rock Creek drainage near Lindsay Ranch in 1994. A group of six birds were apparently using the Lindsay Ranch area for feeding and resting during fall migration. A Category 3 species is one that is no longer under consideration for listing. Such species may continue to be of concern, however.

Three other species of special concern have been reported at RFETS: the American white pelican (*Pelecanus erythrorhynchos*), burrowing owl (*Athene cunicularia*), and forktip three-awn (*Aristida basiramea*) (EG&G 1991c). American white pelicans have been observed periodically on some of the ponds at RFETS, either resting or foraging; the species is common at Standley Lake east of the site. Burrowing owls have also been observed. This species, which is closely associated with prairie dog colonies, occurs in suitable habitat throughout much of the region. The forktip three-awn (a grass) was reported along the railroad tracks north of Woman Creek in 1973 and was documented in the same area in 1991 during vegetation studies at OU5. The toothcup (*Rotala ramosior*), a small wetland plant that is also a species of special concern, has been reported in a temporary pool about 4 miles east of Boulder but has not been documented onsite.

2.3 RFETS Sampling Programs

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Environmental investigations at RFETS have resulted in a large amount of data on baseline conditions and contaminant distribution. Sampling has been conducted for a variety of sampling programs including both monitoring programs and one-time sampling efforts associated with specific sites or OUs. Most of the data have been collected from sites in the Woman Creek and Walnut Creek drainages where past waste disposal and contaminant releases have occurred. However, data are also available for parts of RFETS that are remote from the developed areas

and relatively unimpacted by industrial activities. The types and quality of the data vary among investigations. Much of the data can be obtained from the sitewide Rocky Flats Environmental Database System (RFEDS) or from reports summarizing results of the various investigations. Personnel conducting ERAs at RFETS should review existing data to determine usability in specific risk assessments or to help guide development of future sampling plans. The main sources of data and the programs under which they were collected are summarized below. Personnel that may be contacted to obtain further information on sampling programs are listed in Table 2-4.

Table 2-4
RFETS Monitoring Programs and Personnel Contacts

Program	Contact	Phone
Event-Related Surface-Water Monitoring	Greg Weatherby	966-3687
Sitewide Surface-Water Monitoring	Steve Barros	966-5288
Sitewide Groundwater Monitoring	Steve Singer	966-8635
Annual Sitewide Soil Sampling	Iggy Litaor	966-8583
Ecological Monitoring Program (EcMP)	Mark Bakeman	966-8621
Natural Resource Protection and Compliance Program (NRPCP)	Marcia Murdock	966-3560

2.3.1 Surface Water Chemistry

2.3.1.1 *Event-Related Surface Water Monitoring*

The Event-Related Surface Water Monitoring program (ERSWM) utilizes a network of 17 gaging stations along the major drainages to evaluate changes in surface water hydrology and transport of various chemicals related to rainfall and snowmelt events (Plate 2-7). Data for water years (September to September) 1991 and 1992 are reported in the Event Related Surface Water Monitoring Report, Rocky Flats Plant: Water Years 1991 and 1992 (EG&G 1993a). Data for 1993 (September 1992 to September 1993) are reported in the Event Related Surface Water Monitoring Report for the Rocky Flats Environmental Technology Site for Water Year 1993 (EG&G 1994a). A report for water year 1994 (ended September 1994) is not yet available. Data presented in the reports include:

- Annual hydrographs of mean daily discharge for gaging stations
- Total and suspended radionuclide activity, total metal concentration, and loading data for selected storm events

- Annual RFETS precipitation hyetographs
- Interpretation of metal and radionuclide loading in the RFETS drainages
- Information about the history and development of ERSWM

Data are available for all three major drainages (Rock Creek, Walnut Creek, and Woman Creek) for water year 1992 but only for Woman Creek and Walnut Creek in 1993 and 1994.

2.3.1.2 *Sitewide Surface Water Monitoring Program*

A sitewide surface water and sediment monitoring program was conducted in 1989 and 1990. The results of the monitoring program are reported in the 1989 and 1990 Surface Water and Sediment Geochemical Characterization Reports (EG&G 1992c,d). The overall goals of the monitoring program were to (1) monitor and characterize the surface water and sediment quality at Rocky Flats and (2) assess the significance and impacts of past and potential future contaminant releases to and transport via the surface water pathway (EG&G 1991b,c). The sitewide program has since been discontinued as such and surface water/sediment monitoring now occurs under specific regulatory driven programs including NPDES, RCRA, and OU-specific CERCLA RFI/RI work packages.

Monitoring included analysis of volatile organic compounds, metals, radionuclides, and anions in surface water samples from 82 stations (Plate 2-7). Analysis of both dissolved (sample passed through a 0.45 micron filter) and total (recoverable) chemical concentrations are available for most sites. Field measurement of flow, pH, temperature, and other parameters was conducted at each station. Sediment chemistry was monitored quarterly through collection and analysis of bed material from 24 stations (Plate 2-8). Statistical analyses were conducted to characterize the major-ion chemistry, natural geochemical and spatial trends, and differences between background (unimpacted) and potentially impacted sites downstream of contaminant source areas.

2.3.2 *Sitewide Groundwater Monitoring Program*

The groundwater monitoring program (GMP) at RFETS supports a variety of environmental and engineering investigations in:

- Assessing impacts of potential contaminant sources on groundwater quality

- Evaluating stability and effectiveness of engineered structures such as dams and French drains
- Characterizing hydrologic processes, such as surface water/groundwater interactions and groundwater recharge

The GMP is administered by the Hydrogeologic Operations Group of the Environmental Operations Management Division, which coordinates sampling for the Environmental Restoration Division. Details of the sitewide groundwater monitoring program are presented in the Groundwater Protection and Monitoring Program Plan (EG&G 1993e).

At the end of 1994, the operational groundwater sampling network consisted of 350 wells and 210 piezometers clustered around the industrial area and central Buffer Zone (Plate 2-9). As of January 1995, only two wells were located offsite, downgradient of the Standley Lake and Great Western Reservoir dams. The wells are sampled quarterly or semi-annually as specified by requirements of regulatory compliance programs and OU-specific RFI/RI work plans. Samples are routinely analyzed for volatile organic compounds, semivolatile organic compounds (SVOCs), target analyte list (TAL) metals, and selected radionuclides. However, many wells are consistently dry or lack adequate water to allow analysis of the full suite of chemicals. In these cases, the analytical priorities are determined according to the schedule in the groundwater standard operating procedures (EG&G 1991d). During sample collection, field measurements of temperature, specific conductance, pH, turbidity and purge volume are made and recorded in field log forms. Water levels are measured quarterly in all wells and piezometers and monthly in a subset of the total. These data are used to characterize seasonal and annual fluctuations in the potentiometric surface and to assess interactions between surface water and groundwater.

2.3.3 Soil and Geological Sampling

Soil sampling and analyses have been conducted during a variety of investigations at RFETS. In most cases, chemical analyses are limited to total (recoverable) metal, radionuclide, or organic compound content and, therefore, do not necessarily represent the bioavailable fraction. However, these data are useful in performing screening-level ERAs or when calculation of exposure or ecotoxicological benchmarks includes an adjustment for bioavailability. A primary source of information on soil contamination is the data generated during the RFI/RI programs conducted for each OU. Sampling conducted for RFI/RIs is focussed in and around IHSSs or other source areas. Thus, these data may be used to evaluate exposure in the potentially most

contaminated areas of the site. Sampling sites and methods may be obtained from specific RFI/RI work plans, and results are available from RFEDS or the individual RFI/RI reports (if complete). Data on "background" soils (and sediments) are available from the Background Geochemical Characterization Report (EG&G 1993f).

2.3.3.1 Annual Sitewide Soil Sampling Program

Characterizing plutonium concentrations and potential migration around the perimeter of RFETS is the goal of the Annual Sitewide Soil Sampling Program. Sample locations are arranged in two concentric circles, each consisting of 20 sites located approximately every 18 degrees along the circumference. Sampling occurs annually during the summer and samples are shipped offsite for radiological analyses. Analytical results and a site map were unavailable as of the printing of this document. However, this information should be included in the OU3 RFI/RI Report, and preliminary data may be obtained from the Geosciences Division.

2.3.4 Ecological Sampling Programs

2.3.4.1 Ecological Monitoring Program

The EcMP was initiated in 1993 to comply with DOE Order 5400.1. The EcMP consists of eight modules: terrestrial vegetation, plant nutrients, aquatic ecology, small mammals, soil physical and chemical characterization, soil invertebrates, ecosystem functions, and database development. Each module includes specific data collection and analysis activities that are linked to the overall objectives of the program. Sampling is conducted annually between April and September at permanent locations in the RFETS Buffer Zone. A more detailed summary of EcMP activities can be found in the Rocky Flats Ecological Monitoring Program Annual Report (EG&G 1993b).

Twelve terrestrial monitoring stations were established (Plate 2-10). Ecological surveys for terrestrial sites included the distribution and abundance of plant, small mammal, and soil invertebrate species at each of the 12 stations. Sample collection activities included over 800 vegetation samples representing over 50 species for plant nutrient/trace element analysis and 75 soil samples analyzed for particle size, soil water, pH, carbon, nitrogen, hydrogen, extractable macro/micronutrients, soluble nutrients, cation exchange capacity, total elements, carbonate and bicarbonate (Table 2-5).

Table 2-5

Measurement Endpoints Collected During Field Sampling Operations at Rocky Flats Environmental Technology Site

Environmental Media		Assessment Method	Measurement Endpoint		OU1 OU2 OU3 OU4 OU5 OU6 OU7 IAOU OU11 EcMP NRPCP Baseline NRDA															
Vegetation					Plant Cover Transects	species presence/absence	X	X	X	X	X	X	X	X	X	X	X	X	X	X
				species richness	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
				herbaceous cover	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
				herbaceous production	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
				low shrub production	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
				tree and shrub density	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
				canopy cover	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
				tissue contaminant concentrations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Terrestrial Animals					Arthropod Sweep Transects	species presence/absence	X	X			X				X	X	X	X	X	
				species richness	X	X	X			X					X	X	X	X	X	
				relative abundance	X	X	X			X					X	X	X	X	X	
				tissue contaminant concentrations	X															
Soil Invertebrate Surveys					arthropod id & number										X	X	X	X	X	
				nematode id & number											X	X	X	X	X	
				protozoan id & number											X	X	X	X	X	
				mycorrhizal inoculation potential											X	X	X	X	X	
Bird Surveys					species presence/absence	X	X	X	X	X	X	X	X	X	X	X	X ¹	X	X	X
				species richness	X	X	X	X	X	X	X	X	X	X	X	X	X ¹	X	X	
				relative abundance	X		X								X	X	X	X	X	
				relative density/ha	X	X	X			X	X	X				X ¹	X	X	X	
				tissue contaminant concentrations																
Small Mammal Surveys					species presence/absence	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
				species richness	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
				relative abundance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
				relative density/ha												X				
				tissue contaminant concentrations	X	X	X			X	X	X								
				habitat evaluation												X				
Large Mammal Surveys					species presence/absence	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
				species richness	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
				relative abundance	X	X	X			X	X	X	X	X	X	X	X	X	X	
				pellets/ha	X	X					X	X			X				X	
				tissue contaminant concentrations																

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Table 2-5
Measurement Endpoints Collected During Field Sampling Operations at Rocky Flats Environmental Technology Site

Environmental Media	Assessment Method	Measurement Endpoint										Baseline NRDA
		OU1	OU2	OU3	OU4	OU5	OU6	OU7	IAOU	OU11	EcMP	NRPCP
Aquatic Biota	Amphibian and Reptile Surveys	X	X	X		X	X	X		X		X
	species presence/absence											
	species richness											X
	relative abundance											X
Aquatic Biota	tissue contaminant concentrations											
	Phytoplankton Surveys	X	X			X	X	X		X		X
	species presence/absence											
	species richness	X	X			X	X	X		X		X
Aquatic Biota	relative abundance	X	X			X	X	X		X		X
	relative density/mL											
	biomass											
	biovolume											
Aquatic Biota	Zooplankton Surveys											
	species presence/absence											
	species richness					X	X			X		X
	relative abundance					X	X			X		
Aquatic Biota	relative density/mL	X				X	X			X		
	biomass	X										
Aquatic Biota	Periphyton Surveys	X	X	X		X	X	X		X		X
	species presence/absence											
	species richness	X	X	X		X	X	X		X		X
	relative abundance	X	X	X		X	X	X		X		X
Aquatic Biota	relative density/mm ²	X	X	X		X	X	X		X		X
	pigment concentration											
	tissue contaminant concentrations											
Aquatic Biota	Benthic Macroinvertebrate Surveys	X	X	X		X	X	X		X		X
	species presence/absence											
	species richness	X	X	X		X	X	X		X		X
	relative abundance	X	X	X		X	X	X		X		X
Aquatic Biota	relative density/m ²	X	X	X		X	X	X		X		X
	biomass	X	X			X	X	X				
	tissue contaminant concentrations	X	X				X					
Aquatic Biota	Emergent Insect Surveys											
	species presence/absence									X		X
	species richness									X		X
	relative abundance									X		X
Aquatic Biota	relative density/m ² /day									X		X
	tissue contaminant concentrations											

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Table 2-5
Measurement Endpoints Collected During Field Sampling Operations at Rocky Flats Environmental Technology Site

Environmental Media	Assessment Method	Measurement Endpoint	OU1 OU2 OU3 OU4 OU5 OU6 OU7 IAOU OU11 EcMP NRP/CP Baseline NRDA										
Fish Surveys	species presence/absence		X	X	X		X	X	X	X			X
	species richness		X	X	X		X	X	X	X			X
	relative abundance												X
	tissue contaminant concentrations		X	X	X		X	X	X	X			
Toxicity Testing: Water	<i>Ceriodaphnia</i> reproduction, survivorship		X	X	X		X	X	X	X			
	Fathead minnow survivorship		X	X	X		X	X	X	X			
Toxicity Testing: Sediment	<i>Hyallolella azteca</i> growth, survivorship				X		X	X	X	X			
	<i>Chironomus riparius</i> growth, survivorship						X	X	X	X			
General Observations													
Plant Habitat Characterization	mapping		X	X	X	X	X	X	X	X	X	X	X
	planimetry		X	X	X	X	X	X	X	X	X	X	X
Featured Species ²	species presence/absence		X	X	X	X	X	X	X	X	X	X	X
	habitat use		X	X	X	X	X	X	X	X	X	X	X
	activities		X	X	X	X	X	X	X	X	X	X	X
	relative abundance/time		X	X	X	X	X	X	X	X	X	X	X
Ecosystem Function	extracted soil nitrate										X	X	
	extracted soil ammonium										X	X	
	total soil nitrogen										X	X	
	soil particulate organic matter										X	X	
	microbial nitrogen										X	X	
	microbial carbon										X	X	
	potential mineralizable nitrogen										X	X	
	potential respirable carbon										X	X	
	nitrogen fixation rate										X	X	
	denitrification rate										X	X	
EcMP Plant Tissue Concentrations	soil nutrients										X	X	
	soil metals										X	X	
EcMP Plant Tissue Concentrations	ash										X	X	
	aluminum										X	X	
	cadmium										X	X	
	calcium										X	X	
	chromium										X	X	
	copper										X	X	

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Table 2-5
Measurement Endpoints Collected During Field Sampling Operations at Rocky Flats Environmental Technology Site

Environmental Media	Assessment Method	Measurement Endpoint	OU1 OU2 OU3 OU4 OU5 OU6 OU7 IAOU OU11 EcMP NRPCP Baseline NRDA									
		iron								X	X	
		lead								X	X	
		magnesium								X	X	
		manganese								X	X	
		molybdenum								X	X	
		phosphorus								X	X	
		potassium								X	X	
		sodium								X	X	
		sulfur								X	X	
		zinc								X	X	

¹Limited data available.

²"Featured species" or "significant species" include large mammals, carnivores, lagomorphs, raptors, muskrats, reptiles, prairie dogs, game birds, threatened, endangered, and special concern species, specific surveys are done for these species, and continuous sightings are recorded.

Aquatic ecology data were collected as available from most ponds, streams, springs, and seeps sitewide. A total of 277 aquatic biota samples were collected in 1993, including macrobenthos, emergent insects, zooplankton, phytoplankton, algae, and periphyton. Water chemistry data were also collected from most aquatic sites.

2.3.4.2 Natural Resource Protection Program

The NRPCP monitors the status of several wildlife groups to ensure that operations at RFETS remain in compliance with the five following state and federal wildlife protection statutes:

- The Bald and Golden Eagle Protection Act
- The Endangered Species Act
- The Colorado Non-Game, Threatened, and Endangered Species Conservation Act
- The Fish and Wildlife Coordination Act
- The Migratory Bird Treaty Act

A description of the program objectives and methods is presented in the Rocky Flats Plant Resource Protection Program FY93 Annual Wildlife Survey Report (DOE 1993a).

Routine surveys are conducted to monitor wildlife populations such as game species, high-visibility species, indicator organisms, or species afforded special protection by state and federal statutes. This ongoing monitoring program tracks population trends, habitat use, and species diversity from year to year and serves as an environmental management tool for DOE and its contractors. Data from the NRPCP has been used in preparation of Environmental Evaluations, Environmental Assessments, and Environmental Impact Statements. Continued data collection on wildlife populations at RFETS may also provide background data for Natural Resource Damage Assessment concerns in the future.

Surveys are performed with varying frequency using a wide range of methods. Surveys performed under the NRPCP include:

- Relative Abundance Surveys
- Fortuitous Sightings of Featured Species
- Diurnal and Nocturnal Sitewide Featured Species Surveys
- Migratory Bird Surveys
- Waterfowl Surveys
- Seasonal Use Surveys

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- Migratory Bird Surveys
- Waterfowl Surveys
- Seasonal Use Surveys

- Brood Surveys
- Raptor Surveys
- Big Game Surveys
- Prairie Dog Census Surveys
- Carnivore Surveys

Data on all featured species are archived in the Featured Species Database maintained by the Ecology and Watershed Management Division. The Featured Species Database may be queried for specific habitat affinity data, species numbers, relative abundance, unusual species, sightings of threatened, endangered, or special concern species, or any combination of such data. Data collected through 1993 is presented in the Rocky Flats Plant Resource Protection Program FY93 Annual Wildlife Survey Report (DOE 1993a).

In addition to routine surveys, the NRPCP also conducts site-specific surveys prior to any new activities on the site to ensure regulatory compliance. The specific methods and requirements for these surveys are described in two RFETS procedures:

- Identification and protection of threatened, endangered, and special-concern species (1-D06-EPR-END.03)
- Migratory bird evaluation and protection (1-G98-EPR-END.04)

2.3.4.3 *OU-Specific ERAs*

Field sampling has been conducted for ERAs associated with OUs 1, 2, 3, 4, 5, 6, 7, and 11. In general, the sampling conducted to date has focused on:

- Ecological site characterization
- Broad (i.e., not chemical specific) indicators of population and community stress
- Biological tissue sampling to support exposure analyses
- Aquatic toxicity testing

Ecological (population and community) sampling has involved evaluation of general endpoints such as community composition, richness, and production. This approach was necessary in most

of the ERAs because the nature and extent of contamination was largely unknown, making identification of chemical-specific endpoints difficult. Animal and plant tissues were analyzed for some metals and radionuclides as specific indicators of exposure to these suspected contaminants. In most cases, ecological sampling and tissue analyses also were conducted for reference sites in the Rock Creek drainage to provide an estimate of the baseline ecological community structures and background concentrations in tissues. Some specific ecological and toxicological sampling has been conducted to evaluate polychlorinated biphenyls (PCBs) in the A- and B-series detention ponds (DOE 1994a). The sites sampled during ERA and EcMP field investigations are listed on Plate 2-10. A compilation of the measurement endpoints for each ecological investigation is presented in Table 2-5.

3.0 SITE CONTAMINATION

This section presents a sitewide review of contamination history and type organized by OU and IHSS. Potential contaminant source areas at RFETS were identified on the basis of historical information and environmental data. The descriptions were taken from the Environmental Restoration Technical Support Document (ERTSD) (EG&G 1994c) and are presented by OU.

3.1 IHSS Descriptions

Individual source areas were designated as discrete IHSSs. Each of the more than 150 IHSSs has been assigned to one of 16 OUs (Figure 3-1). The IA/PA includes IHSSs from OUs 4, 8 through 10, and 12 through 16; the Walnut Creek drainage includes IHSSs from OUs 2, 4, 6, 7, and 11; and the Woman Creek drainage includes IHSSs from OUs 1, 2, 5, and 11. The Offsite Areas include IHSSs from OU3. IHSSs included in the Woman Creek and Walnut Creek drainages and the Offsite Areas are listed in Table 3-1. This section provides a brief description of each IHSS.

3.1.1 Operable Unit 1—881 Hillside

3.1.1.1 OUI Site Description

The 881 Hillside area is located south and southeast of Building 881, on the south side of the RFETS security area. Eleven IHSSs are included in OU1 (DOE 1990).

- IHSS 102—Oil Sludge Pit
- IHSS 103—Chemical Burial
- IHSS 104—Liquid Dumping
- IHSS 105.1—Building 881 Westernmost Out-of-Service Fuel Oil Tanks
- IHSS 105.2—Building 881 Easternmost Out-of-Service Fuel Oil Tanks
- IHSS 106—Outfall
- IHSS 107—Building 881 Hillside Oil Leak
- IHSS 119.1—West Scrap Metal Storage Area
- IHSS 119.2—East Scrap Metal Storage Area
- IHSS 130—Contaminated Soil Disposal Area East of Building 881
- IHSS 145—Sanitary Waste Line Leak

Table 3-1
Individual Hazardous Substance Sites

Operable Unit	IHSS Number	IHSS Name
OU1	102	Oil Sludge Pit
	103	Chemical Burial
	104	Liquid Dumping
	105.1 and 105.2	Out-of-Service Fuel Oil Tanks
	106	Outfall
	107	Hillside Oil Leak
	119.1 and 119.2	Scrap Metal Storage Areas
	130	Contaminated Soil Disposal Area
	145	Sanitary Waste Line Leak
OU2	108	Trench T-1
	109	Trench T-2
	110 and 111.1 through 111.8	Trenches %-3 through %-11
	112	903 Pad
	113	Mound Area
	140	Hazardous Disposal Site
	153	Oil Burn Pit No. 2
	154	Pallet Burn Site
	155	903 Lip Area
	183	Gas Detoxification Area
OU3	216.2 and 216.3	East Spray Fields
	199	Contamination of the Land's Surface
	200	Great Western Reservoir
	201	Standley Lake
OU4	202	Mower Reservoir
	101	Solar Evaporation Ponds
OU5	115	Original Landfill
	133.1 through 133.4	Ash Pits I-1 thorough I-4
	133.5	Incinerator
	133.6	Concrete Wash Pad
	142.10 and 142.11	Ponds C-1 and C-2
	196	Water Treatment Plant Backwash Pond
	209	Surface Disturbance Southeast of Building 881

Table 3-1
Individual Hazardous Substance Sites

Operable Unit	IHSS Number	IHSS Name
OU6	141	Sludge Dispersal Area
	142.1 through 142.4 and 142.12	Ponds A-1, A-2, A-3, A-4, and A-5
	142.5 through 142.9	Ponds B-1, B-2, B-3, B-4, and B-5
	143	Old Outfall
	156.2	Soil Sump Area
	165	Triangle Area
	166.1, through 166.3	Trenches A, B, and C
	167.1	Spray Field—North Area
	216.1	East Spray Fields—North Area
OU7	114	Present Landfill
	167.2 and 167.3	Spray Fields—Center Area and South Area
	203	Inactive Hazardous Waste Storage Area
OU11	168	West Spray Field
OU12	116.1	West Loading Dock Building 444
	116.2	South Loading DOck Building 444
	120.1	Fiberglassing Area North of Building 664
	120.2	Fiberglassing Area West of Building 664
	136.1	Cooling Tower Pond West of Building 444
	136.2	Cooling Tower Pond East of Building 444
	147.2	Building 881 Conversion Activity
	157.2	Radioactive Site South Area
	187	Site Sulfuric Acid Spill
	189	Nitric Acid Tanks
OU13	117.1	North Site Chemical Storage
	117.2	Middle Site Chemical Storage
	117.3	Chemical Storage—South Site
	128	Oil Burn Pit No. 1
	134	Lithium Metal Destruction Site
	148	Waste Leaks
	152	Fuel Oil Tank 221 Spills
	157.1	Radioactive Site North Area

**Table 3-1
Individual Hazardous Substance Sites**

Operable Unit	IHSS Number	IHSS Name
	158	Radioactive Site—Building 551
	169	Waste Drum Peroxide Burial
	171	Fire Department Training Ground
	186	Valve Vaults 11, 12, and 13
	190	Caustic Leak
	191	Hydrogen Peroxide Spill
	197	Scrap Metal Sites—500 Area
OU14	131	Radioactive Site—700 Area Site No. 1
	156.1	Building 371 Parking Lot
	160	Radioactive Site—444 Parking Lot
	161	Storage Site West of Building 664
	162	Radioactive Site—700 Area Site No. 2
	164.1	Radioactive Sites from Building 776
	164.2	Radioactive Site 800 Area Site No. 2, Building 886 Spills
	164.3	Radioactive Site 800 Area Site No. 2, Building 889 Storage Pond
OU15	178	Building 881 Drum Storage Area
	179	Building 865 Drum Storage Area
	180	Building 883 Drum Storage Area
	204	Original Uranium Chip Roaster
	211	Building 881 Drum Storage Unit, Unit 26
	217	Building 881 Cyanide Bench Scale Treatment, Unit 32
OU16	185	Solvent Spill
	192	Antifreeze Discharge
	193	Steam Condensate Leak—400 Area
	194	Steam Condensate Lead—700 Area
	195	Nickel Carbonyl Disposal

Information on site use and history is summarized from the Final Phase III RCRA Facility Investigation/Remedial Investigation Work Plan, Revision 1, Rocky Flats Plant, 881 Hillside Area (Operable Unit No. 1) (DOE 1991a) and the Historical Release Report for the Rocky Flats Plant (DOE 1992b).

3.1.1.2 OUI Site Use and History

IHSS 102 (Oil Sludge Pit) was a pit where 30 to 50 drums of nonradioactive oil sludge were emptied in 1958. The sludge reportedly was collected during cleaning of two No. 6 fuel oil tanks (possibly tanks identified as IHSSs 105.1 and 105.2 south of Building 881). IHSS 103 (Chemical Burial) was an area south of Building 881 reportedly used to bury unknown chemicals. The exact location, dates of use, and contents of the site are unknown. No documentation confirms the existence of the site and it may have been confused with IHSS 109 (Trench T-2 in OU2). IHSS 104 (Liquid Dumping) is an area east of Building 881 reportedly used for disposal of unknown liquids and empty drums prior to 1969. No documentation confirms the existence of the site and it may also have been confused with IHSS 109 (Trench T-2 in OU2).

IHSSs 105.1 and 105.2 (Building 881 Westernmost Out-of-Service Fuel Oil Tanks and Building 881 Easternmost Out-of-Service Fuel Oil Tanks) are located immediately south of Building 881. These No. 6 fuel tanks were used from 1958 through 1976. They were filled with asbestos-containing material and then with concrete, presumably in 1976.

IHSS 106 (Outfall) is a 6-inch-diameter, iron-pipe outfall, which existed south of Building 881 and discharged water until December 1977. Initial use of the pipe was to discharge sanitary waste. This practice was halted. The pipe was later used to discharge cooling tower blowdown.

IHSS 107 (Building 881 Hillside Oil Leak) is the location of an oil leak discovered in 1973 on the hillside south of Building 881. The oil had emerged from the Building 881 footing drain outfall. The oil spill was contained with straw, and the straw and soil were removed and disposed in the present landfill north of RFETS. The South Interceptor Ditch (constructed to prevent contamination from entering Woman Creek) and the concrete skimming pond (now replaced by the French drain) were built below the footing drain outfall to contain the oil. No oil has been observed in the outfall since 1973.

IHSS 119.1 (West Scrap Metal Storage Area) and IHSS 119.2 (East Scrap Metal Storage Area), two areas east of Building 881 along the south perimeter road, were used as barrel storage areas. The barrels contained unknown quantities and types of solvents and wastes. All barrels were removed from the sites in 1972. According to the Historical Release Report, a scrap metal pile (IHSS 119.2) was located in the southeast portion of the industrial area. The site was moved to a location approximately 200 yards to the west (IHSS 119.1). The scrap metal may have been contaminated with oils and/or coolants that could have dripped onto the ground.

IHSS 130 (Contaminated Soil Disposal Area East of Building 881) was an area east of Building 881 and northwest of IHSS 119.1 that was used between 1969 and 1972 to dispose of soil and asphalt contaminated with low levels of plutonium. The material was from a removal at Building 776 in 1969, from a section of Central Avenue between Eighth and Tenth Streets replaced in 1970, and from a soil removal at Building 774 in 1972.

IHSS 145 (Sanitary Waste Line Leak) occurred in 1981 when a portion of a 6-inch, cast-iron sanitary sewer line located south of Building 881 leaked. The line conveyed sanitary wastes to the sanitary treatment plant. From 1969 to 1973, the line carried radioactive laundry effluent.

3.1.2 Operable Unit 2—903 Pad, Mound, and East Trenches

3.1.2.1 OU2 Site Description

OU2 consists of IHSSs identified in the Interagency Agreement (IAG) as associated with the 903 Pad, the Mound, and the East Trenches, which are located in the southeast portion of the RFETS security area. The 903 Pad Area consists of five IHSSs.

- IHSS 109—Trench T-2
- IHSS 112—903 Pad
- IHSS 140—Hazardous Disposal Site
- IHSS 155—903 Lip Area
- IHSS 183—Gas Detoxification Area

The Mound Area is composed of four IHSSs:

- IHSS 108—Trench T-1
- IHSS 113—Mound Area
- IHSS 153—Oil Burn Pit No. 2
- IHSS 154—Pallet Burn Site

The East Trenches Area consists of 11 IHSSs:

- IHSS 110—Trench T-3
- IHSSs 111.1 through 111.8—Trenches T-4 through T-11
- IHSSs 216.2 and 216.3—East Spray Fields

Information on site use and history is from the Preliminary Draft, Phase II RFI/RI Report 903 Pad, Mound, and East Trenches Area Operable Unit No. 2 (DOE 1993b). In June 1992, the Final Historical Release Report for the Rocky Flats Plant (DOE 1992b) was released. This document summarizes known data on each IHSS, as well as other releases, and provides more complete information on site use and history.

3.1.2.2 OU2 Site Use and History

IHSS 109 (Trench T-2) is located south of the 903 Pad and west of IHSS 140 (Hazardous Disposal Site). This trench was used prior to 1968 for the disposal of sewage sludge from the onsite sanitary treatment plant and some flattened empty drums. The trench is believed to have been approximately 10 feet wide by 20 feet long by 5 feet deep.

IHSS 112 (903 Pad) was used from 1958 to 1968 for storage of more than 5,000 drums containing radioactively contaminated (uranium or plutonium) oil. Approximately three-fourths of the drums were plutonium-contaminated, and most of the balance contained uranium. Approximately 420 drums leaked to some degree.

Most of the drums stored at the 903 Pad contained lathe coolant oil and carbon tetrachloride. Other liquids, including hydraulic oils, vacuum pump oil, trichloroethylene, perchloroethylene, silicone oils, and acetone, were also contained in the drums. Removal of all drums and wastes was completed in 1968, and the site was capped with asphalt in 1969.

IHSS 140 (Hazardous Disposal Site) is located on the hillside south of the 903 Pad and was used during the 1950s and 1960s primarily for the destruction of lithium metal. Approximately 400 to 500 pounds of metallic lithium were destroyed on the ground surface, and the residues were buried in this area. Smaller amounts of sodium, calcium, magnesium, solvents, nickel carbonyl, and iron carbonyl were also destroyed at this location.

IHSS 155 (903 Lip Area), adjacent to the 903 Pad (IHSS 112), is an area where plutonium, redistributed by wind and rain from the 903 Pad, is believed to have been deposited. Soil removal efforts were undertaken at the Lip Area in 1976, 1978, and 1984. After the 1984 effort, the excavated area was backfilled with clean topsoil.

IHSS 183 (Gas Detoxification Area), located south of the 903 Pad, was used between approximately 1968 and 1983 to detoxify various gases from lecture bottles. The gases consisted of various types of nitrogen oxides, chlorine, hydrogen sulfide, sulfur tetrafluoride, methane,

hydrogen fluoride, and ammonia, which were used in RFETS research and development work. Gas detoxification was accomplished by using various commercial neutralization processes available at the time. Other bottles were packaged and sent to offsite vendors for disposal.

IHSS 108 (Trench T-1) was used from 1954 until 1962 and contains approximately 125 drums filled with approximately 25,000 kilograms of uranium chips and possibly some plutonium. The estimated dimensions of the trench are 15 feet by 200 feet by 5 feet deep. The trench was covered with approximately 2 feet of soil.

IHSS 113 (Mound Area), located north of Central Avenue in the eastern RFETS security area, was used between April 1954 and September 1958 for drum disposal. Approximately 1,405 drums containing primarily depleted uranium- and beryllium-contaminated lathe coolant were placed at the Mound site. It is likely that some drums of the coolant also contained enriched uranium and plutonium. Some drums also contained tetrachloroethene. Removal of all drums from the Mound Area was accomplished in 1970.

IHSS 153 (Oil Burn Pit No. 2) consists of two parallel trenches that were used in 1957 and from 1961 to 1965 (also possibly during the period of 1957 to 1961) to burn approximately 1,082 drums (at least 272 more drums are thought to have been burned) of coolant, still bottoms, and oil containing uranium. Approximately 300 of the emptied drums were flattened and buried in the burn pits. The residues from the burning and flattened drums were covered with backfill. In 1978, the area was excavated and contaminated soil and debris were removed and disposed offsite.

IHSS 154 (Pallet Burn Site) is southwest of the Oil Burn Pit and was reportedly used to destroy wooden pallets in 1965. The site was cleaned up and reclaimed in the 1970s. No documentation exists that verifies the existence of the site.

IHSS 110 (Trench T-3) and IHSSs 111.1 through 111.8 (trenches T-4 through T-11) were used from 1954 to 1968 for disposal of approximately 125,000 kilograms of sewage sludge from the sanitary treatment plant contaminated with uranium and plutonium and approximately 300 flattened drums contaminated with uranium. Trenches T-3, T-4, T-10, and T-11 are located north of the east access road, and trenches T-5 through T-9 are south of the east access road. Recently, trenches T-12 and T-13 have been identified. Trench T-12 is thought to be an extension of Trench T-9. Both are thought to contain sewage sludge.

IHSSs 216.2 and 216.3 (East Spray Fields) were used for spray irrigation of sewage treatment plant effluent. Effluent containing low concentrations of chromium was sprayed in the area in February and March 1989. The spray irrigation areas are located east of trenches T-5 through T-9.

3.1.3 Operable Unit 3—Off-Site Releases

3.1.3.1 OU3 Site Description

Operable Unit 3 is unique among site OUs in that it is located outside the RFETS boundaries. All of the IHSSs in OU3 are located east of the RFETS boundaries (Figure 1-2). Four IHSSs are defined by the 1991 IAG.

- IHSS 199—Contamination of the Land's Surface
- IHSS 200—Great Western Reservoir
- IHSS 201—Standley Lake
- IHSS 202—Mower Reservoir

The actual boundaries of IHSS 199 have not been officially defined. Sampling related to the IHSS 199 effort has occurred north, south, east, and west of RFETS (EG&G 1994d). Information on site use and history is from the Final RFI/RI Work Plan for Operable Unit 3, Rocky Flats Plant (DOE 1992c). The Historic Release Report does not address OU3.

3.1.3.2 OU3 Site Use and History

IHSS 199 (Contamination of the Land's Surface) specifically targets offsite soil contamination as a result of RFETS past releases. IHSS 199 includes approximately 350 acres of land that were part of a lawsuit filed in U.S. District Court by the outside property owners against the United States and other defendants alleging contamination of the land surface by releases from RFETS during its operating history.

A settlement agreement finalized in 1985 required that RFETS undertake remedial action on those portions of the land containing plutonium at concentrations exceeding an action level (0.9 picocuries per gram) adopted by the court from a Colorado Department of Health (now CDPHE) special construction standard for plutonium in soil. To date, remedial activities have been undertaken on 120 acres (owned by Jefferson County) of the 350 acres.

IHSS 200 encompasses Great Western Reservoir, offsite reaches of Walnut Creek (which formerly flowed into the reservoir from RFETS), and downstream surface water features possibly impacted by outflow from the reservoir. Portions of Walnut Creek within RFETS are not included in IHSS 200. Great Western Reservoir is located approximately 1 mile east of the eastern boundary of RFETS. The reservoir is owned by the City of Broomfield and is used solely for Broomfield municipal water supply. The reservoir and surrounding area are fenced and posted to exclude public access. The present reservoir volume is 3,250 acre-feet, and the maximum height of the dam is 69 feet. The reservoir is unlined.

From 1952 through 1979, water containing decontaminated process and laundry effluent, cooling tower blowdown, and treatment system condensate were discharged to Walnut Creek via the B-series ponds. The effluents contained metals, radionuclides, and inorganic ions (especially nitrate) within concentration limits considered acceptable at the time. Radionuclides and metals from these discharges and from inadvertent releases during re-engineering of holding pond dams accumulated in varying amounts in the sediments of the holding ponds (A- and B-series ponds), Walnut Creek, and Great Western Reservoir. Other sources, such as solar pond leakage and herbicide usage, also could have contributed contaminants to Great Western Reservoir.

IHSS 201 encompasses Standley Lake, offsite reaches of Woman Creek (which flows into the reservoir from RFETS), and downstream surface water features possibly impacted by outflow from the reservoir. Standley Lake is a large reservoir located approximately 2 miles southeast of the eastern boundary of RFETS. Uses of the reservoir include municipal water supply for the cities of Westminster, Northglenn, and Thornton; irrigation; and recreation. The reservoir has been owned by the Farmers Reservoir and Irrigation Company of Brighton, Colorado, since its construction between 1909 and 1919. The present volume of Standley Lake is 43,000 acre-feet, and 96 percent of its water comes from Clear Creek via irrigation ditches.

IHSS 202 encompasses Mower Reservoir and offsite reaches of the irrigation ditch, which feed the reservoir from Woman Creek, and downstream surface water features possibly impacted by outflow from the reservoir. Mower Reservoir is a small, privately owned impoundment located southeast of RFETS. The reservoir is fed by Woman Creek via Mower Ditch, an irrigation ditch that originates within the RFETS boundary. Mower Reservoir is used for agricultural purposes and fluctuates in capacity depending upon the water supply and demand. It covers an area of approximately 9 acres and is roughly 5 feet deep at its deepest point. Outflow from Mower Reservoir flows southeast, eventually into Standley Lake.

3.1.4 Operable Unit 4—Solar Evaporation Ponds

3.1.4.1 OU4 Site Description

OU4 includes only one IHSS, IHSS 101 (Solar Evaporation Ponds), which is located in the central portion of RFETS in the northeast part of the PA. IHSS 101 is also known as the Solar Ponds Waste Management Unit. Other areas and features that are considered pertinent to the characterization of OU4 are the Original Pond, the Interceptor Trench System (ITS) (also known as the French drain system), and areas in the immediate vicinity of the solar ponds. The IHSS contains five surface impoundments.

- Pond 207-A
- Pond 207-B North
- Pond 207-B Center
- Pond 207-B South
- Pond 207-C

Specific details concerning the construction of each pond, the trenches, and the ITS are in the Draft Final Phase I RFI/RI Work Plan (DOE 1991b).

Information on the site use and history is from the OU4 Solar Evaporation Pond Interim Measures/Interim Remedial Action, Environmental Assessment (IM/IRA/EA) Decision Document (DOE 1994c). In June 1992, a final Historical Release Report for RFETS was released (DOE 1992b). This document summarizes known data on each IHSS, as well as other releases, and provides more complete information on site use and history.

3.1.4.2 OU4 Site Use and History

The solar ponds were constructed primarily to store and treat by evaporation low-level radioactive process wastes and neutralized acidic wastes containing high nitrites and aluminum hydroxide. During their use, these ponds are known to have received additional wastes such as the following:

- Sanitary sewer sludge
- Lithium metal
- Radioactively contaminated aluminum scrap
- Acid waste

- Sodium nitrate
- Ferric chloride
- Lithium chloride
- Sulfuric acid
- Ammonium persulfates
- Hydrochloric acid
- Nitric acid
- Hexavalent chromium
- Cyanide solutions

Solvents and other organics have not been routinely discharged into the ponds. However, low concentrations of solvents may have been present as a minor constituent in other wastes.

The Original Pond was constructed in 1953 and removed by 1970. Pond 207-A was placed into service in August 1956. Ponds 207-B, North, Center, and South were placed into service in June 1960. Pond 207-C was constructed in 1970 to provide additional storage capacity and to allow transfer and storage of liquids from the other ponds. The design of Pond 207-C included a leak detection pipe and sump.

These ponds were formerly used to store and treat liquid process wastes having less than 100,000 picocuries per liter (pCi/L) of total long-lived alpha activity (DOE 1980). Subsequent construction activities included the installation of interceptor trenches Nos. 1 through 6 and two sumps during the period from April 1970 through July 1974 to prevent natural seepage and pond leakage from entering North Walnut Creek. This system has been replaced by the current ITS, which was installed in April 1981.

Sludges from the Solar Evaporation Ponds have been removed from time to time to implement repair work on the pond liners. From 1976 to 1977, the '207-B ponds were cleaned and decommissioned. Soils were removed from between ponds, and Pond 207-B South was relined using Hypalon. As the sludges were removed from Pond 207-A in 1986, they were mixed with Portland cement in Building 788 and solidified as a mixture of sludge and concrete (pondcrete) for shipment to an offsite low-level radioactive waste disposal site. The final sludge was removed from Pond 207-A in 1988.

3.1.5 Operable Unit 5—Woman Creek Priority Drainage

3.1.5.1 OU5 Site Description

Ten IHSSs, geographically located along or within the drainage areas of Woman Creek, were originally designated as OU5, Woman Creek Priority Drainage. The IHSSs are identified in the 1991 IAG as:

- IHSS 115—Original Landfill
- IHSS 133.1—Ash Pit I-1
- IHSS 133.2—Ash Pit I-2
- IHSS 133.3—Ash Pit I-3
- IHSS 133.4—Ash Pit I-4
- IHSS 133.5—Incinerator
- IHSS 133.6—Concrete Wash Pad
- IHSS 142.10—C-1 Pond
- IHSS 142.11—C-2 Pond
- IHSS 196—Water Treatment Plant Backwash Pond
- IHSS 209—Surface Disturbance Southeast of Building 881

IHSS 196 was not identified with OU5 in the IAG. The investigation and remediation work associated with this IHSS was transferred to OU5 from OU16 for logistical reasons according to correspondence dated May 27, 1993, from the Colorado Department of Health (CDH 1993).

Two additional surface disturbances have been identified and are included in the OU5 Work Plan (DOE 1992d). One disturbance is located south of the Ash Pits, and the other is west of IHSS 209.

The boundaries for each IHSS are the same as those established in the IAG, except for IHSS 115 (Original Landfill) and IHSS 209 (Surface Disturbances Southeast of Building 881). The southern boundary of the landfill has been extended approximately 300 feet south across the SID. The boundary of IHSS 109 has been extended north and southwest.

Information on the site use and history is from the Final Phase I RFI/RI Work Plan, Woman Creek Priority Drainage (Operable Unit No. 5) (DOE 1992d) and the Historical Release Report for the Rocky Flats Plant (DOE 1992b).

3.1.5.2 OU5 Site Use and History

The natural drainage of Woman Creek has been modified in the OU5 area by the construction of the C-series ponds and the SID. The purpose of the SID is to collect runoff from the security zone before it reaches Woman Creek. Water from the SID is diverted to detention Pond C-2.

IHSS 115 (Original Landfill) is located within the Buffer Zone south of the 400 Area security fence and south of the west access road. The Original Landfill covers approximately 7.5 acres. It was operated from 1952 to 1968 and was used to dispose of general wastes and unknown nonradioactive hazardous chemical wastes. It is estimated that 2 million cubic feet of miscellaneous RFETS wastes are buried in the Original Landfill, including solvents, paint thinners, paints, pesticides, and cleaners. The Original Landfill also received beryllium and/or uranium wastes and wastes containing PCBs and may have been used as a graphite dump. In the late-1970s, hotspots containing depleted uranium were uncovered in the landfill. These hotspots were removed in one box of soil in July 1979.

The Original Landfill was closed with a soil cover (date unknown); however, a bottom liner was not installed. The slope on the south side of the Original Landfill has been regraded to correct sloughing and erosion-related problems. The surface of the Original Landfill is hummocky and irregular.

IHSSs 133.1, 133.2, 133.3, and 133.4 (Ash Pits 1 through 4); IHSS 133.5 (Incinerator); and IHSS 133.6 (Concrete Wash Pad) are located south-southwest of the 400 Area security area along the north slope of Woman Creek. The four ash pits were used to dispose of ash from the incinerator. Ash from the incinerator may also have been pushed over the side of the hill into the Woman Creek drainage and/or onto the Concrete Wash Pad. Following the shutdown of the incinerator, the Ash Pits were covered with unknown fill. The incinerator was used between 1952 and 1968 to burn general RFETS wastes and small quantities of depleted uranium-contaminated combustibles (<100 grams). Depleted uranium is also believed to have been burned in the incinerator. The incinerator was removed by 1971. The Concrete Wash Pad appears to be an area that was used primarily to wash waste concrete from concrete trucks used during construction of the plant facilities.

IHSS 142.10 (C-1 Pond) and IHSS 142.11 (C-2 Pond) are located along Woman Creek, southeast of the 400 Area security area and within the Buffer Zone. The C-series ponds were constructed to control surface water runoff from the Industrial Area and from Woman Creek and

to provide monitoring of waters discharged from ponds 6, 7, and 8, which were located near Woman Creek and abandoned in the early 1960s.

Pond C-1 was constructed in 1955. Filter backwash water from the water treatment facility was discharged to Pond C-1 between plant start-up in 1952 and December 1973. Cooling tower blowdown water was discharged to Pond C-1 until late 1974. In the early 1970s, plant operations changed and this pond was used principally to manage surface water runoff in the Woman Creek drainage. Pond C-1 now serves as a flow-through retention pond and its discharges bypass Pond C-2 and are returned to the natural channel below Pond C-2.

Pond C-2 was constructed in 1979 to control surface water runoff and to serve as a spill control pond. Water from the SID feeds into Pond C-2, which now discharges into the Broomfield Diversion Ditch.

Other problems and/or releases known to have occurred in the C-series drainage include untreated sanitary sewage, steam condensate from Building 881, resuspended soils and runoff from the 903 Pad, and runoff from the East Spray Field.

IHSS 196 (Water Treatment Plant Backwash Pond) was located approximately 800 feet south of Building 124. Through the early 1970s, backwash from the raw water treatment plant was collected in the unlined pond. Reportedly, the pond dried up and was destroyed in the late 1970s. The area is now a grassy meadow.

IHSS 209 (Surface Disturbance Southeast of Building 881) is located southeast of Pond C-1. The 5.2-acre area is thought to have been a borrow pit. No known disposal activities took place at this site; however, RFETS has agreed, as part of the IAG, to investigate the pit as a potential disposal site.

In addition to IHSS 209, there are two other surface disturbances in the proximity of IHSS 209 that are being investigated as part of the Phase I RFI/RI process for OU5. These two areas are being investigated as potential disposal sites. The first disturbance is located approximately 1,500 feet west of IHSS 209 and consists of four small disturbed areas symmetrically placed around a fifth disturbed area (total area is approximately 52,500 square feet).

The second disturbance is located approximately 1,200 feet south of IHSS 133 (Ash Pits, etc.) and south of Woman Creek. The area consists of five former excavation areas visible at ground level but primarily visible from aerial photographs.

3.1.6 Operable Unit 6—Walnut Creek Priority Drainage

3.1.6.1 OU6 Site Description

Until recently, 21 IHSSs made up OU6, which encompasses the drainages of North and South Walnut Creeks. The 1991 IAG identified 20 IHSSs within OU6, and another IHSS (156.2) was added because of its proximity to the OU. Also, the investigation and remediation work associated with IHSSs 167.2 and 167.3 was transferred from OU6 to OU7 for logistical reasons in correspondence dated May 27, 1993, from the Colorado Department of Health (CDH 1993). The remaining 19 IHSSs are:

- IHSS 141—Sludge Dispersal Area
- IHSS 142.1—Pond A-1
- IHSS 142.2—Pond A-2
- IHSS 142.3—Pond A-3
- IHSS 142.4—Pond A-4
- IHSS 142.12—Flume Pond (IAG name: A-5 Pond)
- IHSS 142.5—Pond B-1
- IHSS 142.6—Pond B-2
- IHSS 142.7—Pond B-3
- IHSS 142.8—Pond B-4
- IHSS 142.9—Pond B-5
- IHSS 143—Old Outfall—Building 771 (IAG name: Old Outfall)
- IHSS 156.2—Soil Dump Area
- IHSS 165—Triangle Area
- IHSS 166.1—Trench A
- IHSS 166.2—Trench B
- IHSS 166.3—Trench C
- IHSS 167.1—Spray Field: North Area (IHSSs 167.2 and 167.3 to OU7)
- IHSS 216.1—East Spray Fields—North Area

Information on site use, history, and nature and extent of contamination was derived from the OU6 RFI/RI Work Plan (DOE 1992e) and the Historical Release Report (DOE 1992b).

3.1.6.2 OU6 Site Use and History

IHSS 141 (Sludge Disposal Area) straddles the eastern perimeter of the PA and the Buffer Zone, just west of Pond B-1. Two corrugated metal buildings that cover the present-day drying beds of the STP in Building 995 are located within this IHSS. Two paved roads cross the IHSS in a north-south direction: one is within the PA, and the other is within the Buffer Zone. A drainage ditch separates the roads, is outside of the PA, and empties into the B-series ponds. Prior to 1983, IHSS 141 received airborne radioactive particles from dried-sludge packaging operations. The sludge was generated by the STP. Radioactive laundry effluent was the only known radioactive effluent entering the drying beds between 1969 and 1972. By the latter half of 1972, plumbing changes were made and all RFETS wastes were channeled through the STP and then into the drying beds, resulting in increased radioactivity levels in the sludges. Also, an overflow incident at Building 701 in June 1972 contributed elevated levels of plutonium to the effluent entering the STP.

IHSSs 142.1, 142.2, 142.3, and 142.4 (ponds A-1, A-2, A-3, and A-4) are located along North Walnut Creek. According to the OU6 RFI/RI Work Plan, the A-series ponds received discharges from several sources (DOE 1992e). Between 1952 and 1979, Pond A-1 was used to hold laundry wastewater that contained nitrates and radioactive substances, including plutonium and uranium, that was discharged into North Walnut Creek from the production facilities on the north side of the IA. Pond A-1 also received process liquid waste, cooling tower blowdown, and steam condensate discharges, which contained chromates and algicides. After construction of Pond A-2 (and prior to 1978), the water in Pond A-1 was allowed to flow into Pond A-2 where it evaporated or was spray evaporated. Pond A-3 was constructed in 1971, and Pond A-4 was constructed in 1980. Both of these ponds have been used to impound water from upstream.

IHSS 142.12 (Flume Pond) is located downstream of Pond A-4 and west of Indiana Street. This pond receives treated water discharged downstream of Pond A-4 and runoff from the immediate area. Water from upper Walnut Creek is temporarily detained in the Flume Pond (named the A-5 Pond in the IAG) until it reaches a level high enough to flow out and downstream into lower Walnut Creek. The effluent from the Flume Pond is sampled daily when it discharges downstream, and flow measurements are taken at this pond using two Parshall Flumes (6-inch throat and 36-inch throat).

IHSSs 142.5, 142.6, 142.7, 142.8, and 142.9 (ponds B-1, B-2, B-3, B-4, and B-5) are located along South Walnut Creek. Historically, several waste disposal activities have been associated with the B-series ponds since the beginning of RFETS operations in 1952 (DOE 1992e).

Between 1952 and 1973, decontaminated process water and laundry wastewater were released into South Walnut Creek and subsequently into the ponds. Nitrate, plutonium, and uranium were contained in these wastes; however, the volume of waste is unknown. Ponds B-1 and B-4 also received sanitary effluent from the sewage treatment plant. Pond reconstruction activities conducted between 1971 and 1973 resulted in disturbances to the pond sediments, which caused much of the upstream sediment to migrate to Pond B-1. Subsequently, this increased the total plutonium inventory in the B-series ponds.

IHSS 143 (Old Outfall—Building 771) is located northwest of Building 771 and the Guard Station (Building 773) within the PA and discharges into North Walnut Creek. The IHSS is approximately 30,000 square feet in area and has been covered with fill. Temporary trailers are currently on or near this IHSS. Because of the construction activities in this area, the existing drainage systems are different from the drainage system that existed during the operation of the Old Outfall. The Old Outfall acted as a catchment basin for liquids from various sources, the main one being the laundry holding tanks in Building 771. Liquid wastes from the holding tanks in Building 771, which contained plutonium, were discharged into the Old Outfall area if plutonium concentrations were found to be below 3,300 disintegrations per minute per liter (d/m/L). It is estimated that between 1953 and 1957, 4.5 million gallons of liquid were released into the Old Outfall. In 1957, a waste line was installed to transfer these liquids from the holding tanks to Building 774. However, periodic releases occurred between 1957 and 1965 as a result of occasional equipment problems. During this period, 434,000 gallons of liquid containing 0.25 microcuries (mCi) of plutonium were released to the Old Outfall.

IHSS 156.2 (Soil Dump Area) is located within the Buffer Zone, north of Pond B-1, and covers approximately 5.9 acres. The IHSS is located on an east-west trending interfluvial separating North and South Walnut creeks. A dirt road follows the ridge line of this interfluvial. Between 50 and 75 dump-truck loads of soil containing low levels of plutonium were placed here. Sources of the soil are thought to be soil excavated for a multiple building construction project ("Part V" project, which included Buildings 707 and 774) and sediments from Pond B-5 discharge outlet modification activities.

IHSS 165 (Triangle Area) is located primarily within the PA between the NE Perimeter Road on the north and Spruce Avenue on the south. The IHSS covers approximately 5.7 acres and overlaps slightly with IHSS 176. Fencing for the PA crosses the eastern one-third of this IHSS in a north-south direction. IHSS 165 is not paved, is sparsely vegetated, and has been partially covered with gravel fill of unknown thickness. The Triangle Area is presently used as a storage yard for various types of equipment and pipes.

Between 1966 and 1975, IHSS 165 (Triangle Area) was used as a storage site for miscellaneous wastes. Beginning in 1966, it was used as a storage area and for drums for Building 883. Drums were originally placed directly on the ground, but beginning in 1967, they were placed on pallets. The drums contained scrap materials (graphite molds, crucibles, incinerator ash heels, crucible heels, Raschig rings, and combustible wastes), which were stored in the area until they could be processed for plutonium in Building 771. Waste from a 1969 fire in Building 776 was drummed and held at the Triangle Area until it could be processed at Building 771. By 1968, about 5,000 drums were being stored. High winds in 1968 were responsible for damaging many drums located at the Triangle Area, and leaking drums were found periodically from 1969 to 1973. Some contaminated soil was removed and shipped offsite in 1969. From 1969 to 1970, drums were also placed in cargo containers to help prevent leakage. These cargo containers were shipped for disposal to Idaho in 1975. In addition, some contaminated areas were treated with a strippable coating to prevent resuspension of waste into the air.

IHSS 166.1, 166.2, and 166.3 (trenches A, B, and C) are located north of the PA on a plateau separating North Walnut Creek and the unnamed tributary to the north. IHSS 166.1 (Trench A) is estimated to be 40 feet by 190 feet and is located approximately 100 feet southeast of the Present Landfill. IHSS 166.2 (Trench B) is approximately 40 feet by 190 feet and is located approximately 125 feet south of Trench A. IHSS 166.3 (Trench C) consists of two separate trenches. The first one is estimated to be 30 feet by 200 feet and is located between trenches A and B. The second one is approximately 20 feet by 100 feet and is located approximately 300 feet east of Trench A. Little documentation is available on the operation of these trenches. The trenches are assumed to have been active (based on aerial photographs) on the following dates: Trench A—1964 to 1974; Trench B—1959 to unknown date; and Trench C—1964 to 1974. The trenches are thought to have been used to dispose of uranium- and/or plutonium-contaminated sludge from the Sewage Treatment Plant (Building 995).

IHSS 167.1 (Spray Field—North Area) is located north of North Walnut Creek and the PA. The North Area is estimated to be 3.96 acres in area and is partially located on the plateau areas that bound the unnamed tributary on North Walnut Creek. The spray field is presently covered by grasses common to RFETS. The periods during which the spray field was used are not precisely known, although the field is known to have been used shortly after the Present Landfill became operational in 1968. The field was used solely for spray evaporation of two ponds located east of the Present Landfill (IHSS 114). The East Landfill Pond (the existing landfill pond) was used to intercept groundwater that may have been contaminated by leachate generated at the landfill and was used for spill control. The West Landfill Pond (no longer present) was used to

impound leachate generated by the landfill. It was covered in May 1981 with the expansion of the landfill.

IHSS 216.1 (East Spray Fields—North Area) is located in the Buffer Zone, northeast of the northeastern boundary of the PA. It is on an east-west trending interfluvium that separates North and South Walnut creeks (in the vicinity of the A-series and B-series ponds) and covers approximately 3.4 acres. It became operational in 1989 to provide an additional area to accommodate the spray evaporation of Pond B-3, which collects local surface runoff and the treated effluent from the STP. As a result of excessive runoff problems, use of this field ceased shortly after it came on-line in 1989.

3.1.7 Operable Unit 7—Present Landfill and Inactive Hazardous Waste Storage Area

3.1.7.1 OU7 Site Description

OU7 consists of four IHSSs. IHSSs 167.2 and 167.3 were not identified with OU7 in the 1991 IAG. The investigation and remediation work associated with these IHSSs was transferred from OU6 to OU7 for logistical reasons according to correspondence dated May 27, 1993, from the Colorado Department of Health (now CDPHE). The four IHSSs are:

- IHSS 114—Present Landfill
- IHSS 167.2—Spray Field; Pond Area (Center Area)
- IHSS 167.3—Spray Field; South Area
- IHSS 203—Inactive Hazardous Waste Storage Areas

Information on site use and history is from the Phase I RFI/RI Work Plan, Present Landfill, IHSS 114, and Inactive Waste Storage Area, IHSS 203, Operable Unit No. 7 (DOE 1991c). Information on site use, history, and nature and extent of contamination for IHSSs 167.2 and 167.3 was derived from the OU6 Work Plan (DOE 1992e) and the Historical Release Report (DOE 1992b).

3.1.7.2 OU7 Site Use and History

IHSS 114 (Present Landfill) is located to the north of the plant security area on the western end of an unnamed tributary of North Walnut Creek. Landfill operations were initiated in August 1968, and the landfill is still in use (DOE 1991c). At one time, there were two ponds downstream of the landfill. The western pond was covered by landfill expansion in 1981. The

east pond (Pond 2) was constructed in 1974 to protect surface water and groundwater from contamination by leachate generated in the landfill.

The Present Landfill was designed for disposal of nonradioactive solid waste from RFETS, including paper, rags, floor sweepings, cartons, mixed garbage and rubbish, demolition materials, and miscellaneous items. Hazardous waste that was sent to the landfill includes paints, solvents, degreasers, oil filters, metal cuttings and shavings (including mineral and asbestos dust), and miscellaneous metal chips coated with oils and carbon tetrachloride. From 1968 to 1978, the landfill received approximately 20 cubic yards of compacted waste per day. Beginning in 1973 to the present, after dumping, each waste layer is monitored for radiation and then covered with 6 inches of soil. When the waste-soil layers are within 3 feet of final elevation, the lift is completed with a 3-foot-thick layer of compacted soil.

In 1973, tritium was detected at the drainage of the landfill. In response, the two ponds were constructed and sampling was initiated. During 1974 and 1975, surface water controls and a groundwater diversion and leachate collection system were constructed to address the presence of an apparent tritium source. The volume of material in the present landfill is currently estimated to be approximately 405,000 cubic yards.

IHSSs 167.2 and 167.3 (Spray Fields—Pond Area and South Area) are located north of North Walnut Creek and the PA. The Pond Area is estimated to be 0.72 acres in area, and the South Area is estimated to be 0.92 acres. The South Area is partially located on the plateau areas that bound the unnamed tributary on North Walnut Creek. The Pond Area is located on a north-facing slope of the Present Landfill Pond. These spray fields are presently covered by grasses common to RFETS.

The periods during which these spray fields were used are not precisely known, although the fields are known to have been used shortly after the Present Landfill became operational in 1968. The fields were used solely for spray evaporation of two ponds located east of the Present Landfill (IHSS 114). The East Landfill Pond (the existing landfill pond) was used to intercept groundwater that may have been contaminated by leachate generated at the landfill and was used for spill control. The West Landfill Pond (no longer present) was used to impound leachate generated by the landfill. It was covered in May 1981 with the expansion of the landfill.

IHSS 203 (Inactive Hazardous Waste Storage Area) is located on the southwest corner of the Present Landfill. The storage area was actively used between 1986 and 1987. The Inactive Hazardous Waste Storage Area was operated as a hazardous waste storage area for both

drummed liquids and solids. Fifty-five-gallon containers with free liquids were stored within 14 cargo containers. One additional container was used to store spill control items such as oil sorbent and sorbent pillows.

During maximum inventory, the hazardous waste area consisted of 8 20-foot-long cargo containers, each capable of holding 18 55-gallon drums, and 6 40-foot-long cargo containers, each capable of holding 40 55-gallon drums. RCRA-listed wastes were stored in 12 of the 14 cargo containers and included solvents, coolants, machining wastes, cuttings, lubricating oils, organics, and acids. Two of the cargo containers were used to store PCB-contaminated soil and debris, as well as PCB-contaminated oil from transformers taken out of service. In May 1987, all of the containers were removed from the site. The area has been vacant since then.

3.1.8 Operable Unit 11—West Spray Field

3.1.8.1 OU11 Site Description

OU11 consists of only one IHSS and covers an area of approximately 105 acres.

- IHSS 168—West Spray Field

IHSS 168 is located west of the T-130 trailers. Between April 1982 and October 1985, three areas of the WSF were used for periodic spray application of excess liquids pumped from the Solar Evaporation Ponds 207-B Center and 207-B North. Pond 207-B Center was a repository for effluent from the Sewage Treatment Plant, which processes sanitary waste from the plant. Pond 207-B North was a repository for water from the interceptor trench system. The interceptor trench system was installed to collect groundwater and seepage from the hillside north of the Solar Evaporation Ponds and water from Buildings 771 and 774 footing drains. The combined spray area was approximately 41 acres. Information on site use, history, and nature and extent of contamination is from the Technical Memorandum Revised Field Sampling Plan and Data Quality Objectives, OU11 (DOE 1994d) and the Historical Release Report (DOE 1992b).

3.1.8.2 OU11 Site Use and History

IHSS 168 (West Spray Field) was operated from April 1982 to October 1985. During operation, excess liquids from Solar Evaporation Ponds 207-B North and 207-B Center were pumped

periodically to the West Spray Field for spray application. The purpose of the spraying was to dispose of the liquids through evaporation and irrigation.

The ponds received water from the interceptor system installed to collect groundwater seepage at the solar ponds and treated sanitary effluent from the sanitary wastewater treatment plant. Spray application was conducted using moving and fixed irrigation lines with impulse heads and using a spray impulse cannon. Runoff of liquids and windblown spray beyond the boundaries of the spray field are documented on aerial photographs.

Total application rates for the spray field were between 250 and 450 gallons per minute. Spraying generally occurred in intervals of 6 to 10 hours daily for periods of two to four days. The estimated maximum total application could have been as much as 190 inches per acre for 14.1 acres for all four years of operation.

3.1.9 Operable Unit 12—400/800 Area

3.1.9.1 OU12 Site Description

The boundaries of OU12 fall within the Building 400, 600, and 800 areas, located in the southwestern portion of RFETS. OU12 originally consisted of 12 IHSSs identified by the 1986 Comprehensive Environmental Assessment and Response Program (CEARP)—now Environmental Restoration Management—and in the 1991 IAG. According to the OU12 Work Plan (DOE 1992g), on April 21, 1992, IHSS 147.1 was transferred for investigation and remediation to OU9 (Original Process Waste Lines). Further, the work plan indicated that the existence of IHSS 136.3 could not be documented in the Rocky Flats Historical Release Report, could not be investigated, and was, therefore, dropped from OU12.

The 10 IHSSs designated within OU12 are:

- IHSS 116.1—West Loading Dock Building 444
- IHSS 116.2—South Loading Dock Building 444
- IHSS 120.1—Fiberglassing Area North of Building 664
- IHSS 120.2—Fiberglassing Area West of Building 664
- IHSS 136.1—Cooling Tower Pond West of Building 444
- IHSS 136.2—Cooling Tower Pond East of Building 444
- IHSS 147.2—Building 881 Conversion Activity
- IHSS 157.2—Radioactive Site South Area

- IHSS 187—Site Sulfuric Acid Spill
- IHSS 189—Nitric Acid Tanks

The Final Phase I OU12 RFI/RI Work Plan was prepared in October 1992 and was approved November 2, 1992 (DOE 1992g). The descriptions of the sites and contamination are based on the OU12 Work Plan and the Historical Release Report (DOE 1992b).

3.1.9.2 OU12 Site Use and History

IHSSs 116.1 and 116.2 consist of two loading dock areas: the west and the south loading dock areas in the vicinity of Buildings 444 and 447. No details concerning specific releases from the docks have been documented; however, drums containing nonradioactive solvents may have been stored on the west dock, and oil was stored nearby at Building 453. The location of IHSS 116.2 has been revised from the original IAG location based on recent investigations.

According to the Historical Release Report, an accident released uranium to the dock, surrounding walk, and driveways. The south dock was covered with airborne oxide when a fire was extinguished. Also, prior to 1970, chlorinated hydrocarbons were disposed of near the dock.

IHSS 136.1 and 136.2 were used as retention ponds from 1956 to 1969 to contain and evaporate cooling towers blowdown and cleaning solution from Building 447 and possibly Building 444 (DOE 1992g). After the liquid evaporated, the area was backfilled. The former location of the west pond is now occupied by Building 460, aboveground tanks, and paving.

IHSS 157.2, the Radioactive Site South Area, is located within a secured area and includes soil and paved areas surrounding Buildings 439, 440, 444, and 447. The OU12 work plan cites concerns involving low levels of uranium and chemical contamination associated with storage practices, solvent disposal, spills and releases, fires, and process line incidents.

A sulfuric acid spill occurred in 1970 east of Building 443 when an aboveground tank containing the acid began leaking through a flange. The fire department initially began neutralizing the tank and area with lime. The lockout chain was cut, and the acid was allowed to drain to the 448 mixing tank and then to the 443 neutralizing tank. The tank was allowed to empty. Because of a lack of secondary containment facilities, a certain amount of the acid drained into the stormwater system in a ditch running south of Building 442 and to a ditch running northeast of Building 442. Ponds were constructed to collect the contents of the latter flow. Acid was

also removed from the neutralization tank (due to leakage in the sanitary sewer), packed in drums, and placed in earthen pits southeast of Building 442. No documentation exists concerning removal of contaminated soil; however, photos suggest soil was excavated.

IHSS 189 (Nitric Acid Tanks) involves numerous spills occurring primarily during the transfer of nitric acid at two 10,000-gallon storage tanks located at receiving area 218 (east of Building 444). Incidents have been reported from 1952 to 1986. Spilled material was reportedly neutralized with sodium bicarbonate or washed down with water to dilute the acid and disperse it on the ground.

Two areas north and west of Building 664 (IHSSs 120.1 and 120.2) were used for fiberglassing waste packaging boxes from 1972 to 1979. Although the Historical Release Report found no documentation detailing releases, possible spills of polyester resin, peroxide catalysts, and cleaning solvents may have occurred in these areas.

According to the OU12 work plan, IAG data indicated that low-level radioactive waste contamination was thought to exist north of Building 881 as a result of leaks in the process waste lines; however, there are no process waste lines in the area of IAG IHSS 147.2. Research for the Historical Release Report indicates this contamination may have been associated with conversion of the building from uranium-manufacturing activity to metal fabrication (1964 to 1966), in which case, conversion items were stored farther northeast of the building. No documentation could be found in Historical Release Report research that indicated a release resulting from conversion activities in the IAG location. The Historical Release Report recommends moving the IHSS to the conversion activity storage area.

3.1.10 Operable Unit 13—100 Area

3.1.10.1 OU13 Site Description

Fifteen IHSSs currently compose OU13. A modification to the 1991 IAG transferred the investigatory and remediation work associated with IHSS 122 from OU13 to OU9 for logistical reasons according to correspondence dated April 21, 1992 (CDH 1992). In addition, the work associated with IHSS 197 was transferred from OU16 to OU13 according to correspondence dated May 27, 1993 (CDH 1993). The IHSSs in OU13 are:

- IHSS 117.1—North Site Chemical Storage
- IHSS 117.2—Middle Site Chemical Storage

- IHSS 117.3—Chemical Storage—South Site
- IHSS 128—Oil Burn Pit No. 1
- IHSS 134—Lithium Metal Destruction Site
- IHSS 148—Waste Leaks
- IHSS 152—Fuel Oil Tank 221 Spills
- IHSS 157.1—Radioactive Site North Area
- IHSS 158—Radioactive Site—Building 551
- IHSS 169—Waste Drum Peroxide Burial
- IHSS 171—Fire Department Training Ground
- IHSS 186—Valve Vaults 11, 12, and 13
- IHSS 190—Caustic Leak
- IHSS 191—Hydrogen Peroxide Spill
- IHSS 197—Scrap Metal Sites—500 Area

Detailed site investigations have not been conducted at OU13, but a work plan has been prepared. The following descriptions of the sites and contamination are based on the Final Phase I RFI/RI Work Plan, Rocky Flats Plant, 100 Area (Operable Unit No. 13) (DOE 1992h); the Final No Further Action Justification Document, Rocky Flats Plant Low-Priority Sites (Operable Unit 16) (DOE 1992i); and the Historical Release Report (DOE 1992b).

3.1.10.2 OU13 Site Use and History

IHSSs 117.1, 117.2, and 117.3 (Chemical Storage Sites) consist of three sites used for general and chemical storage prior to the mid-1970s. The North Site Chemical Storage (IHSS 117.1) was used as a general warehouse storage yard and may have contained scrap metal; the Middle Site Chemical Storage (IHSS 117.2) was used as a nonradioactive chemical storage facility and storage for pallets, wooden boxes, cargo containers, and new drums; and the Chemical Storage—South Site (IHSS 117.3) was used as storage and may have contained wooden boxes and drums. Drums containing acids, oils, soaps, solvents, and beryllium scrap metal were stored at the Middle Site Chemical Storage (IHSS 117.2).

IHSS 128 (Oil Burn Pit No. 1) was a pit in which 6 or 10 (conflicting reports) drums of waste oil containing depleted uranium were burned in August 1956. After burning, the pit was covered with soil. The waste oils were generated in Building 444 and 881. Building 335 is identified as being located over the pit, although the location may actually be under Sage Avenue and the Sage Avenue Ditch based on review of aerial photographs.

IHSS 134 (Lithium Metal Destruction Site) consisted of shallow trenches or pits. The trenches were filled with water, and lithium metal (powder) was disposed of by reaction with the water. The residues left from the reaction were then covered with soil. The site operated between 1956 and 1970. It is believed that approximately 400 to 500 pounds of lithium, as well as small amounts of metallic sodium, calcium, magnesium, and possibly graphite, were disposed of in this way. Parts of Building 335 near Sage Avenue are presently located over the site. Additional burning occurred near Building 331. This site may be added as an IHSS (proposed 134.2), while the former location would be identified as IHSS 134.1

IHSS 148 (Waste Leaks) consists of several small spills of nitrate wastes around the outside of Building 123. Dates and volumes of the spills are unknown. Spilled wastes may have contained radionuclides.

IHSS 152 (Fuel Oil Tank 221 Spills) consists of one 50-foot-diameter surface fuel tank that contains No. 6 fuel oil. In January 1971, the fuel tank overflowed while being filled, and approximately 700 gallons of fuel oil was confined to ditches and the open field east of the tank. The area was cleaned up, and the oil was recycled. In February 1979 and 1984, similar spills of 400 gallons and 50 gallons, respectively, occurred.

IHSS 157.1 (Radioactive Site North Area) was produced when laundry operations in Building 442 caused radioactive contamination of the soil around the building. Barrels stored near the building may have contributed some of the contamination. The laundry operation was in operation from 1953 until approximately 1972.

IHSS 158 (Radioactive Site—Building 551) is an area used to load boxed radioactive wastes into railroad container cars. Residual radioactive contamination may have remained at the site from leaks and damaged boxes. In July 1963 and again in 1970, an area to the north of Building 551 received drums and equipment from offsite that were contaminated with uranium above acceptable levels. The areas around Building 551 are suspected of contamination because of these and other minor incidences.

IHSS 169 (Waste Drum Peroxide Burial) consisted of a leaking 55-gallon drum of hydrogen peroxide that was reportedly buried in IHSS 117.2 (Middle Site Chemical Storage) east of Building 551. The area is now paved and used for storage.

IHSS 171 (Fire Department Training Ground) is an area east of Building 335 used by RFETS firefighters for training from 1969 to the present. The firefighters have burned waste solvents, diesel fuel, and plenum filters.

IHSS 186 (Valve Vaults 11, 12, and 13) was caused by various leaks and damages to pipes. Leaks have caused solution to enter Valve Vault 13 (June 1985); Valve Vault 12 (September 1988); and Valve Vaults 11, 12, and 13 (October 1989). Damaged or leaking pipes have lead to solution being released near Valve Vault 13 (June 1985), between Valve Vaults 12 and 13 (October 1986), and between Building 374 and Valve Vault 13 (June 1987). Soil around the leakage sites in the October 1986 incident was removed and shipped offsite. No release of contamination occurred with the June 1985 and June 1986 incidents.

IHSS 190 (Caustic Leak) occurred in 1978 when approximately 1,000 gallons of concentrated sodium hydroxide were accidentally released from the Steam Plant catch basin to the Central Avenue Ditch. The liquid was diverted to Pond B-1 and neutralized with alum. The liquid was eventually transferred to Solar Evaporation Pond 207-B North.

IHSS 191 (Hydrogen Peroxide Spill) occurred in April 1981 when a 55-gallon drum of hydrogen peroxide was dropped at the corner of 5th Street and Central Avenue. The drum ruptured, and the liquid was contained in a hole dug at this location. The hole was subsequently covered. The area has been paved since the time of the spill.

IHSS 197 (Scrap Metal Sites—500 Area) southwest of Building 559 was used for disposal of scrap nonradioactive, nonhazardous, and nonprecious metals accumulated primarily during construction activities and from process areas. The sites were removed in the early 1980s when the PA was constructed. Material extracted from the sites was monitored to determine the presence of radioactivity and was found to be clean. The residue was placed in the Present Landfill. One of the sites may have received used transformers that contained PCBs; however, no transformers were found during the excavation.

3.1.11 Operable Unit 14—Radioactive Sites

3.1.11.1 OU14 Site Description

Operable Unit 14 currently consists of eight IHSSs that are considered radioactive sites and have not been previously grouped into other operable units. The IHSSs in OU14 are:

- IHSS 131—Radioactive Site—700 Area Site No. 1
- IHSS 156.1—Building 371 Parking Lot
- IHSS 160—Radioactive Site—444 Parking Lot
- IHSS 161—Storage Site West of Building 664
- IHSS 162—Radioactive Site—700 Area Site No. 2
- IHSS 164.1—Radioactive Sites from Building 776
- IHSS 164.2—Radioactive Site 800 Area Site No. 2, Building 886 Spills
- IHSS 164.3—Radioactive Site 800 Area Site No. 2, Building 889 Storage Pond

CDPHE and EPA have moved IHSS 156.2 (Soil Dump Area), from OU14 to OU6 (CDH 1992). Detailed site investigations have not been conducted at OU14. The descriptions of the sites and contamination are based on the Final Phase I RFI/RI Work Plan, Rocky Flats Plant, Radioactive Sites (Operable Unit No. 14) (DOE 1992j) and the Historical Release Report (DOE 1992b).

3.1.11.2 OU14 Site Use and History

IHSS 131 (Radioactive Site—700 Area Site No. 1) consists of two areas. The first contains approximately 1,500 square feet (one report stated 40 square feet) and is north of Building 776, and the second contains approximately 2,000 square feet and is west of Building 776. These areas may have been contaminated by plutonium following an explosion in 1964 and during firefighting efforts after the 1969 fire. The areas have subsequently been covered with seal coat and gravel. Precise boundaries of IHSS 131 are not defined.

IHSS 156.1 (Building 371 Parking Lot) is an area where low-level plutonium-contaminated soil collected around Building 774 was placed in the area now covered by the Building 334 parking lot. The soil was removed from that location prior to construction of the parking lot and moved to IHSS 165 (Triangle Area in OU6) and then to the landfill. However, the location is now shown to be under the Building 371 parking lot and is identified as IHSS 156.1 based on review of aerial photographs. (The 1991 IAG identified this IHSS as the Building 334 Parking Lot.)

IHSS 160 (Radioactive Site—Building 444 Parking Lot) and IHSS 161 (Storage Site West of Building 664) are sites within the 600 Area that may have received low-level radioactive contamination from plutonium and uranium. Punctured and leaking waste drums and boxes containing both solid and liquid wastes contaminated with uranium and plutonium were stored in the area of the Building 444 parking lot and staged in Building 664. Surface soil was removed from the Building 444 parking lot and the areas east and west of the Building 444

parking lot and west of Building 664 in the early 1970s. Small amounts of plutonium and uranium may have remained.

IHSS 162 (Radioactive Site—700 Area Site No. 2) was identified in 1974 when several radioactive spots on 8th Street were located during pavement monitoring. The street was paved over to immobilize the contaminated spots.

IHSS 164.1 (Radioactive Site 800 Area Site No. 2, Concrete Slab), IHSS 164.2 (Radioactive Site 800 Area Site No. 2, Building 886 Spills), and IHSS 164.3 (Radioactive Site 800 Area Site No. 2, Building 889 Storage Pad) consist of three contaminated areas within the 800 area. The areas are presently covered by relatively new cement sidewalks, parking lots, and driveways. In 1958, an area several hundred square feet in size (IHSS 164.1), located northwest of Building 881 and southwest of Building 883, was radioactively contaminated from a concrete slab that had been removed from the east wall of Building 776. The slab was broken up and removed, and the area was cleaned up.

Two other areas within the 800 Area have also been contaminated with uranium. Spills involving uranium have resulted in possible infiltration under and around Building 886 (IHSS 164.2). A storage pad north of Building 889 (IHSS 164.3) was used temporarily to store contaminated drums and uranium-contaminated equipment prior to decontamination procedures. The volume and type of radioactive compounds is unknown.

3.1.12 Operable Unit 15—Inside Building Closures

3.1.12.1 OU15 Site Description

Operable Unit 15 currently consists of six IHSSs that are located within RFETS buildings. CDPHE and EPA modified the original IAG list for OU15, and IHSS 215 is now included in OU9 (CDH 1992). IHSS 212 (Building 371 Drum Storage, Unit 63) has been removed from the IAG schedule for OU15 because it is an active RCRA storage site (EG&G 1994d). The IHSSs in OU15 are:

- IHSS 178—Building 881 Drum Storage Area
- IHSS 179—Building 865 Drum Storage Area
- IHSS 180—Building 883 Drum Storage Area
- IHSS 204—Original Uranium Chip Roaster
- IHSS 211—Building 881 Drum Storage Unit, Unit 26

- IHSS 217—Building 881 Cyanide Bench Scale Treatment, Unit 32

Detailed site investigations have not been conducted at OU15, but a work plan has been prepared. The descriptions of several of the sites and contamination are based on the Final Phase I RFI/RI Work Plan, OU15, Inside Building Closures (DOE 1993c) and the Historical Release Report (DOE 1992b).

3.1.12.2 OU15 Site Use and History

IHSS 178 (Building 881 Drum Storage Area) is a 5-foot by 5-foot area located in Room 165 of Building 881. The area was first used in 1953 and is still in use for less than 90-day storage. Up to five 55-gallon drums containing waste that have hazardous and possibly low-level radioactive constituents are stored in the area.

IHSS 179 (Building 865 Drum Storage Area) is an 8-foot by 12-foot area located in Room 145 of Building 865. The area was first used in 1970 and is currently designated as a 90-day accumulation area. Up to 10 55-gallon drums can be stored in the area. Until 1986, wastes containing oils, chlorinated solvents, and possibly beryllium could be stored. Since 1986, only waste containing oils possibly contaminated with beryllium and radioactive constituents have been stored there.

IHSS 180 (Building 883 Drum Storage Area) is a 10-foot by 16-foot area located in Room 104 of Building 883. The area has been used since 1981 and, for part of that time, was used as a RCRA 90-day accumulation area. It is currently used to store low-level (not mixed) radioactive waste. A maximum of 30 55-gallon drums containing waste oils contaminated with solvents and uranium have been stored in the area.

IHSS 204 (Original Uranium Chip Roaster) is located in Rooms 32 and 502 of Building 447. This unit is constructed of mild steel casing and lined with alumina refractory brick. It was used to convert pyrophoric elemental uranium to an oxide for safe storage and transport.

IHSS 211 (Building 881 Drum Storage, Unit 26) is in Room 266B of Building 881 and measures 20 feet by 10 feet. The area was first used in 1981 and is currently used as a 90-day accumulation area. Up to 29 55-gallon drums of low-level mixed (primarily laboratory process) wastes have been stored in the area.

IHSS 217 (Building 881 Cyanide Bench Scale Treatment, Unit 32) was produced when bench-scale treatment of hazardous waste occurred. The treatment involved the analysis of laboratory wastes for cyanide content. After treatment, the wastes were collected in a 4-liter polyethylene bottle and oxidized to form cyanate. Once the process was complete, the bottle was poured into the process waste system. This unit is no longer in use, and an interim status closure plan for the unit was submitted to CDPHE/EPA in 1988.

3.1.13 Operable Unit 16—Low-Priority Sites

3.1.13.1 OU16 Site Description

Operable Unit 16 currently consists of five IHSSs that are categorized as low-priority sites. The IHSSs in OU16 are:

- IHSS 185—Solvent Spill
- IHSS 192—Antifreeze Discharge
- IHSS 193—Steam Condensate Leak—400 Area
- IHSS 194—Steam Condensate Leak—700 Area
- IHSS 195—Nickel Carbonyl Disposal

CDPHE and EPA modified the original IAG list for OU16. IHSSs 196 and 197 are now assigned to OU5 and OU13, respectively (CDH 1993). Discussions regarding these IHSSs will be found in the appropriate OU sections.

Detailed site investigations have not been conducted at OU16. The descriptions of the sites and contamination are based on the Final No Further Action Justification Document, Rocky Flats Plant Low-Priority Sites (Operable Unit 16) (DOE 1992i) and the Historical Release Report (DOE 1992b). OU16 is scheduled to be closed under a "No Action" Record of Decision (EG&G 1994d).

3.1.13.2 OU16 Site Use and History

IHSS 185 (Solvent Spill) resulted when a forklift punctured a 55-gallon drum of 1,1,1-trichloroethane at the southeast loading dock of Building 707 in 1986. The drum was sealed, placed in an overpack drum, and sent to the Rocky Flats Hazardous Waste Group for disposal. A commercial absorbent was used to clean up the spill and then placed in a drum. Conflicting reports have the absorbent being taken offsite or to Hazardous Storage.

IHSS 192 (Antifreeze Discharge) occurred in December 1980 when approximately 155 gallons of 25 percent ethylene glycol were released from a chiller unit into a floor drain in Building 708 and drained into the stormwater system. The flow was contained by diverting the stormwater discharge into South Walnut Creek, which flows into Pond B-1.

IHSS 193 (Steam Condensate Leak—400 Area) was produced in November 1979 when a steam condensate line between Building 443 and a valve pit north of the gasoline storage tank leaked. Water analyses indicated a low concentration of amines. This line was taken out of service, and the condensate was rerouted through a different system.

IHSS 194 was produced in September 1979 when a steam condensate line broke near Building 707 and water from this line flowed through Pond B-4 into Walnut Creek.

IHSS 195 (Nickel Carbonyl Disposal) occurred in 1972 when several cylinders of nickel carbonyl were destroyed in a hole drilled in the Buffer Zone northwest of the RFETS production area. The valves were opened and the cylinders were lowered into the hole by rope. After 24 hours, the cylinders were removed, punctured, and buried in the Present Landfill. Two cylinders became wedged in the hole and were buried in place. The exact location of the borehole is unknown.

3.2 Potential Contaminant Types

Based on information collected from each OU in the Woman and Walnut Creek drainages, a variety of chemicals is suspected to be present in a variety of media at levels above background. The types of contaminants suspected in Woman and Walnut Creek drainages include metals, radionuclides, SVOCs, including polycyclic aromatic hydrocarbons (PAHs) and PCBs; SVOCs that can be ecologically significant; volatile organic compounds (VOCs); and some water-quality parameters. Media of potential concern include surface and subsurface soils, groundwater, surface water, and sediments. Potential contaminant types for each OU in the Woman and Walnut Creek drainage basins are summarized by medium in Table 3-2. Appendices A and B include tables that list potential contaminants of concern (PCOCs) by medium for each OU in the Walnut and Woman Creek drainage basins. It is important to note that PCOC selection for OU1 predates the Gilbert methodology; therefore, the OU1 PCOC selection was performed with different statistical tests than the other OUs. In addition, no PCOC determinations are currently available for OUs 4 and 11.

Table 3-2
Summary of PCOCs by Medium for Woman and Walnut Creek Drainage Basins

Potential Contaminant of Concern	Woman Creek Drainage Basin			Walnut Creek Drainage Basin		
	OU1 ¹	OU2	OU3 ²	OU2	OU6	OU7
	gw	ss, bh, gw, sw, sd	ss, bh, gw, st	ss, bh, gw	ss, bh, gw, sw, sd	ss, bh, gw
Metals	ss, bh, sw, sd	ss, bh, gw	ss, bh, gw, st, sp, sd	ss, bh, gw	ss, bh, gw, sw, sd	ss, bh, gw
Radionuclides	ss, bh, sd	ss, bh, gw	ss, bh, gw, st, sd	ss, bh	ss	ss, bh, gw
Semivolatile Organic Compounds	ss, bh, sd	ss, bh, gw	ss, bh, gw, st, sd	ss, bh	ss	ss, bh, gw
PAHs	ss, sd	ss, bh	ss, bh	ss, bh	ss	ss, bh, gw
PCBs	gw, bh, sw, sd	bh, gw	bh, gw, st, sp, sd	bh, gw	bh, gw, sw, sd	ss, gw
Volatile Organic Compounds		bh, gw	st	bh, gw		
Water-Quality Parameters						

bh = borehole (subsurface soil)

gw = groundwater

sd = sediment

sp = seep

ss = surface soil

sw = surface water

st = stream

¹OU1 PCOCs were selected using different statistical tests than the other OUs.

²PCOCs in surface water in OU5 were further designated by type of surface water (streams and seeps).

4.0 SITEWIDE CONCEPTUAL MODEL

This section presents a sitewide conceptual model that describes the categories of stressors, contaminant sources, release mechanisms, transport pathways, exposure routes, and receptor guilds present at RFETS. This general model provides the basis for identifying key receptor species for which exposures will be estimated. Specific components of the model can then be used in individual ERAs as appropriate or in sitewide risk assessment efforts. Model food webs are described for use in evaluating exposure through biological pathways. A brief description of the SCM for the Woman Creek and Walnut Creek drainages is also presented. Detailed SCMs, including site-specific contaminant concentrations and exposure models, will be developed and presented in the PF TM for each ERA.

Evaluation of ecological risk is usually based on effects to populations or ecosystem functions, except where federal- or state-protected species are concerned (EPA 1992, 1994). However, exposure and toxicity analyses are usually based on effects to individuals because the most reliable information is based on ecotoxicological studies conducted using individual organisms (Suter 1993). Thus, the SCM described in this section is designed to help characterize exposure of individual plants and animals to site-specific stressors at RFETS.

Where appropriate, results of exposure analyses should be extrapolated to population effects. Quantitative extrapolation to community or ecosystem effects is less reliable because of the complex interactions between the biological and abiotic components of the environment. However, where available and appropriate, measures of ecosystem function should be used in the effects assessment portion of the ERA. For example, some contaminants can alter natural nitrogen cycling in soils and change the vegetation community composition. While the precise cause of alterations in nutrient cycling may be difficult to demonstrate, the presence or absence of such effects may be useful in evaluating impacts to overall ecosystem function. Use of ecosystem function must also consider the scales of the potential source areas and the area over which the effects are being evaluated. Many of the source areas at RFETS are relatively small (< one hectare) compared to the watersheds for which risk may be evaluated. Current or future (i.e., modeled) effects at the watershed level may be difficult to attribute to a particular IHSS and, therefore, may be of limited use in evaluating remedial alternatives for small source areas.

4.1 Stressor Types

As noted in Section 1.0, the baseline ERAs will focus on the potential effects of chemical stressors released during operation of the industrial facilities at RFETS. The characteristics of

COCs will be addressed in detail in the PF TM produced for each ERA. In addition, the potential ecotoxicity is described, and proposed environmental benchmarks are documented in Toxicological Benchmarks for Screening Contaminants of Potential Concern (ORNL 1994). Although physical and biological stressors are not the focus of baseline ERAs at RFETS, understanding them is important in interpreting potential effects of chemical stressors. A brief discussion of the important stressors is presented below. A detailed discussion of the role of these stressors in ecological risk will be included in the individual ERA reports.

4.1.1 Physical Stressors

The dominant physical stressors of ecological systems at RFETS are altered flow regimes of natural streams and physical disturbance of native habitats by industrial activities. As noted in Section 2.0, Woman Creek and Walnut Creek are intermittent streams fed primarily by groundwater seeps and subsurface discharge of groundwater to the stream channels (EG&G 1995). RFETS is located in the headwater areas of both streams. The impermeable surface of parking lots, roads, and buildings in the IA/PA has reduced the infiltration of rain and snowmelt on the pediment and altered the recharge rate of groundwater in this area. The reduced infiltration has also led to increased runoff, which is diverted through storm drains and ditches to Walnut Creek and Woman Creek. The net effects on flow of either creek are currently unknown.

Flow in Walnut Creek is heavily managed through collection of water in the A- and B-series detention ponds (Plate 2-4). Release of water from Pond A-4, the terminal pond in the detention system, is irregular and of relatively short duration (one to three days). As a result, lotic habitat in Walnut Creek between the detention ponds and Great Western Reservoir has been altered from the natural state of the stream system as a result of limited and unpredictable flows induced by human management.

Flow in Woman Creek is also managed and probably has been altered from natural patterns. Flow is diverted for agricultural purposes from Coal Creek Ditch west of RFETS through the Woman Creek channel to a point just north of Pond C-2, then diverted away from the natural channel through Farmer's Ditch. Thus, flow in the upper reaches of Woman Creek may be greater and more persistent than expected under natural conditions, whereas flow in the lower reaches may be lower and less persistent.

The effects of past physical disturbance resulting from industrial activities also is apparent in areas outside the IA/PA. Some areas have been disturbed through remediation activities and are dominated by bare ground or weedy vegetation.

The numerous wide roads have been a physical stress on the natural systems they bisect, serving as dispersal corridors for several noxious weed species such as Russian thistle, cheatgrass, knapweed, and smooth brome. Also, non-DOE activities (i.e., Western Aggregates, Inc. gravel mining activities) may be responsible for invasion of exotic plant species.

4.1.2 Biological Stressors

The vegetation of some areas of RFETS shows evidence of attempts to stabilize surface soils by planting exotic and aggressive grass species, such as smooth brome, in disturbed areas. This is especially evident in the grasslands at the southeastern corner of the site and just east of the 903 Pad Area (Plate 2-3). As is typical of areas reclaimed in this manner, the vegetation community is much less diverse than native areas, as the reclamation species inhibit the invasion and establishment of natural "pioneering" species typical of the early stages of plant succession.

Other examples of introduced species include the largemouth bass found in Pond A-2 and feral cats in the Walnut Creek drainage. These areas have been highly modified for RFETS industrial activities, and the habitats, especially the detention ponds, do not represent native habitat types. Thus, the community effects of these species are difficult to determine. Bass are strictly carnivorous, upper-level consumers that feed on crayfish, aquatic insect larvae, and smaller fish. Their presence in Pond A-2 increases the length of aquatic food chains and may increase the potential for contaminant transfer from sediments and surface water (Rasmussen *et al.* 1990).

4.2 Sitewide Exposure Pathway Model

The exposure pathways model (EPM) describes the contaminant transport and exposure mechanisms important in evaluating exposure of ecological receptors to contaminants at RFETS. The EPM is an important part of the SCM because it provides the mechanism for identifying complete exposure pathways and relating the exposure pathways to measurement endpoints to be used in estimating exposure.

Exposure pathways describe the mechanisms by which contaminants are released, transported, and taken up by receptors (EPA 1989a). An initial objective of an ERA is to identify exposure pathways that are potentially complete and, therefore, should be evaluated in the exposure

analysis (EPA 1992, 1994). The characterization of exposure pathways includes identification of the primary source of a contaminant, the primary mechanisms by which it is released and transported from the source, the point of potential contact with ecological receptor(s) (exposure point), and the mechanism by which the contaminant is taken up by the receptor (exposure route) (EPA 1989a,b). These components can be further defined as involving primary or secondary sources and release mechanisms.

After a contaminant has been released to the environment (primary release), it will enter an environmental medium and be transported to a point of exposure or to another environmental medium, from which secondary release and secondary exposure can occur. Primary and secondary transport can result in an expanded area of contamination and increase the potential for exposure of biotic receptors. The most important abiotic media—soil, surface water, and sediment—may act both as sources of direct exposure to a variety of plant and animal groups and as entry points for contaminant movement into the food web. Food web transfer can further distribute contaminants and result in concentration at higher trophic levels. However, food web interactions are generally important only for contaminants that bioaccumulate, either through bioconcentration or biomagnification.

The types, sources, and distribution of contaminants in abiotic media will be determined using data from abiotic sampling associated with the RFI/RIs at RFETS. These data also will be used to identify COCs and to estimate exposures. In some cases where potentially ecotoxic concentrations were known to occur, additional data on contaminant distribution and/or bioavailability were collected to reduce uncertainty in exposure estimates.

4.2.1 Primary and Secondary Contaminant Sources and Release Mechanisms

Most of the historical releases of contaminants at RFETS occurred as a result of accidental spills, leaking storage containers, buried waste, or emissions of airborne chemicals from processing areas (Section 3.0). Many of the spills and leaks resulted in contamination of soils in the immediate vicinity of the release. Many of the release sites have been documented and identified as IHSSs (Figure 3-1). Thus, soils in IHSSs are the most common primary source of contaminants at RFETS (Figure 4-1).

Contaminants adhering to soil particles may be transported away from the primary source areas through erosion or desorbed and carried away in surface water or into groundwater through infiltration and percolation. Primary release mechanisms may also include biological uptake and transport from the area by mobile species. The result is a wider distribution of contamination

at the sites and creation of secondary sources of contaminants. Secondary sources may be soils, groundwater, surface water, or sediments downgradient of the primary source areas. Some secondary sources at RFETS have been identified and designated as IHSSs. Further release and transport can result in tertiary and quaternary contaminant sources.

Some secondary source areas may receive and accumulate contaminants transported from multiple primary source areas. Sediments in the A-, B-, and C-series ponds and in depositional areas of streams at RFETS are especially important for three reasons. First, they provide a concentrated source of contaminants in areas remote from the primary source area. Second, they integrate inputs from all sources in drainage and may contain a greater number of contaminants than any single IHSS. Third, sediments may provide a continual source of contaminants to aquatic biota and wildlife that use the ponds intensively.

4.2.2 Abiotic Exposure Points

Exposure points are areas and/or media where biota may contact contaminants. Based on data from RFI/RI field investigations, the following environmental media have been identified as exposure points in abiotic media:

Soils

- Surface soils (approximately 0–15 cm deep) in IHSSs or other source areas
- Subsurface soils (deeper than about 15 cm) in IHSSs
- Surface soils downgradient of IHSSs or other source areas
- Subsurface soils downgradient of IHSSs or other source areas

Groundwater

- Shallow groundwater (< 6 feet below surface) in IHSSs or other source areas
- Shallow groundwater (< 6 feet below surface) downgradient from IHSS or other source areas in areas of known groundwater contamination, including seep areas

Surface Water

- Surface water downgradient of soil IHSSs, including seeps and springs downgradient from burial trenches
- Walnut Creek from headwaters east to Great Western Reservoir, including A- and B-series detention ponds
- Woman Creek from headwaters east to Standley Lake, including Pond C-1
- South Interceptor Ditch, including Pond C-2

4.2.3 Exposure Routes

Vegetation, wildlife, and aquatic organisms can be exposed to contaminants through direct contact with contaminated media (air, soil, sediment, water) or indirectly through consumption of forage or prey that have themselves been directly or indirectly exposed to contaminants. The mechanisms by which a contaminant may be taken up are the exposure routes. The main exposure routes at RFETS are ingestion of contaminants in food, soil, and water and absorption across external body surfaces.

Direct dermal exposure to contaminated soil is the main exposure route of concern for vegetation and soil invertebrates. Soil contaminants may be absorbed through the root system and distributed to aboveground plant parts. Plants differ greatly in their ability to absorb chemicals from the soil matrix and in their sensitivity to absorbed contaminants. Soil invertebrates also are subject to dermal absorption of contaminants in soil and may ingest soil during burrowing and feeding activities.

Burrowing vertebrates also may be exposed to soil contaminants during digging and grooming activities. Dermal absorption is not an important exposure route for heavy metals or radionuclides but may be in the case of organic chemicals. Contact with contaminated soil may be of less concern for more wide-ranging species such as deer, coyotes, or birds because they spend less time in contact with the soil in source areas. However, ingestion of soil during feeding is a potential problem in areas with high concentrations of contaminants or sparse vegetation (Arthur and Alldredge 1979). Although deer ingest large quantities of vegetation while grazing, terrestrial invertebrates may be more important herbivores at the site because of their larger total ingestion rate and biomass.

Inhalation of volatilized organic contaminants is a potentially important pathway for animals burrowing in areas of contaminated soil or groundwater. Volatilized organics may tend to accumulate in the restricted air space of the burrow. The young of several species spend most or all of their time within burrows and, therefore, may be subject to sustained exposures. Inhalation of VOC contaminants in ambient air in aboveground locations will not be assessed because of the relatively low surface soil concentrations and because VOCs do not tend to accumulate in open air spaces.

Direct exposure to contaminated surface water is a potential exposure pathway for both terrestrial and aquatic species. Terrestrial vertebrates may ingest substantial quantities of water and become exposed to water-borne contaminants. Aquatic species are vulnerable to water-borne

contaminants because they spend all or most of their lives submersed in the water and are confined to a relatively small area. The absorption of dissolved chemicals from the water column and the subsequent accumulation in internal tissues is known as bioconcentration. Dissolved metals and non-polar organic compounds resistant to metabolism are particularly subject to bioconcentration.

Rooted aquatic plants and aquatic animals that live on or in the substrate may also be exposed to contaminants in sediments. Contaminants may be absorbed as a result of direct contact with sediment particles or dissolved constituents in interstitial water. Sediment contact can be a main point for entry of contaminants into aquatic-based food webs.

4.2.4 Food Web Interactions and Biological Pathways

Food web interactions are most important for chemicals that bioaccumulate (DOE 1991a, Fordham and Reagan 1991). Bioaccumulation can result in toxic exposure, even when the ambient concentrations are relatively nontoxic. It can also result in toxic exposure to receptors that are not exposed to contaminants in abiotic media but feed on organisms that are. Bioaccumulation occurs by absorption and selective accumulation of a chemical directly from environmental media or through accumulation of contaminants ingested with food or water. Bioconcentration is the process of absorption and accumulation of chemicals from environmental media, usually water. Biomagnification is the successive accumulation of a pollutant in biota tissues with increasing trophic levels and is a significant mechanism of bioaccumulation for persistent organic chemicals such as chlorinated pesticides and some organo-metals such as methyl-mercury. In general, the inorganic forms of metals do not biomagnify, but many are known to bioconcentrate (Martin and Coughtrey 1982, Moriarty 1983). Ingestion is usually the most important intake mechanism leading to biomagnification. For most contaminants, the highest bioaccumulation potentials occur in an aquatic-based food web where bioconcentration from contaminated sediment or water accounts for a large proportion of the total bioaccumulation (Fordham and Reagan 1991).

Food web analyses in ecological and environmental investigations are conducted for a variety of reasons, including characterizing energy flow, describing community structure, and predicting changes in populations (Pimm 1982, Krebs 1985, DeAngelis 1993). In this document, food webs are characterized to identify the predominant pathways by which upper-level consumers not normally exposed to contaminated media may be exposed to contaminants through their food sources. This information is used in Section 5.0 to select representative species for which exposures will be estimated.

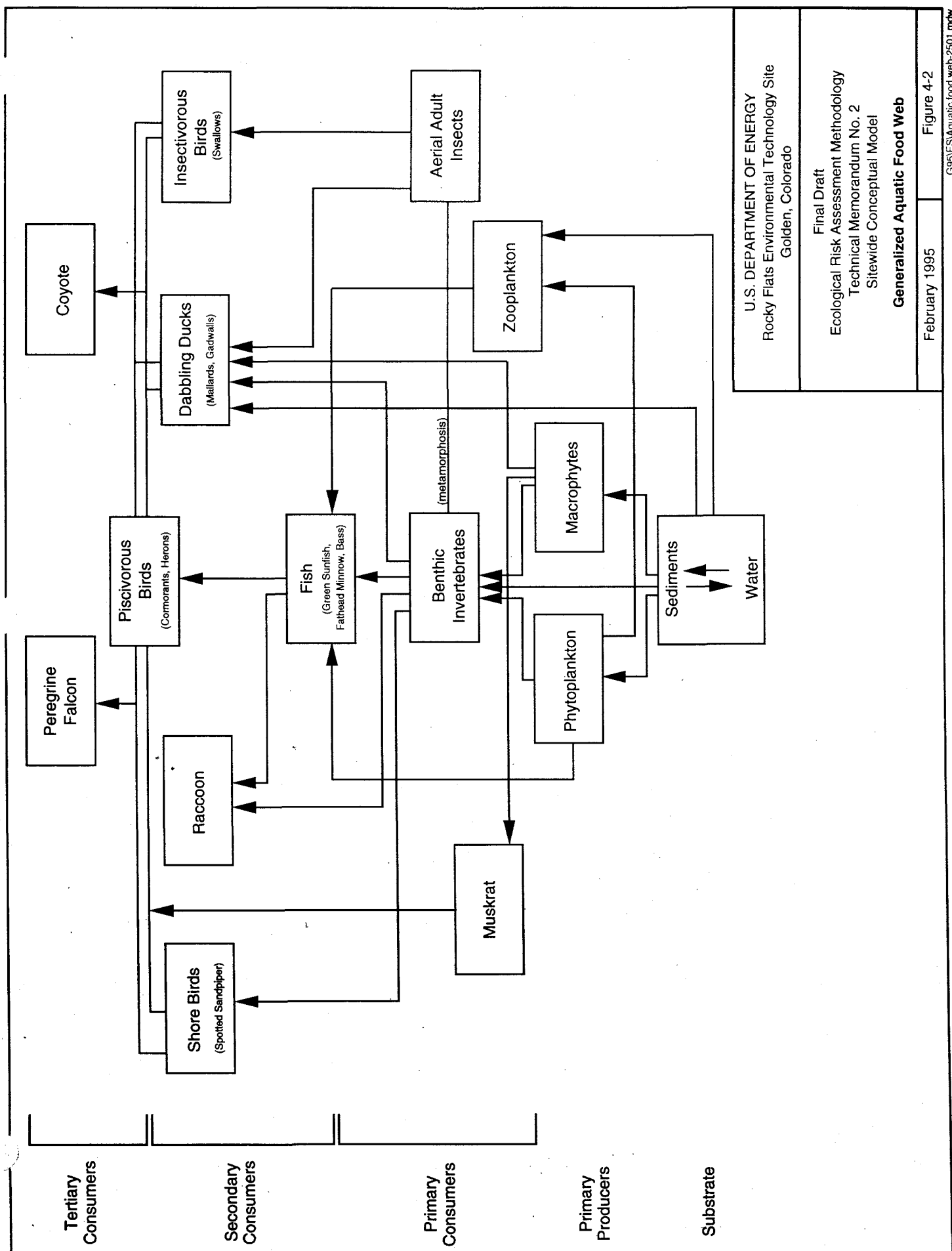
The food webs at RFETS were divided into aquatic and terrestrial "guilds" (Krebs 1985) because of the disparate mechanisms of contaminant distribution and transfer to consumers. Guilds are groups of species exploiting a common resource base in a similar way (Krebs 1985). For the sitewide conceptual model, guilds were used to identify groups of species that use the same food resource (i.e., the aquatic and terrestrial food webs). The aquatic-based food web includes species that acquire all or part of their food from stream, pond, and marshland habitats along the drainages at RFETS (Figure 4-2). The terrestrial-based food web includes species that obtain all or part of their resources from the grassland, shrubland, or riparian (excluding areas of emergent vegetation) areas of RFETS (Figure 4-3). Overlap may result from upper-level consumers that acquire food from both guilds or at the interface of the aquatic and terrestrial habitats such as wetlands and riparian areas. A summary of the functional (trophic) groups and structural strata is represented in Figures 4-2 and 4-3. A more complete list of species included in each group is presented in Table 4-1. Note that members of all trophic (feeding) levels may come in direct contact with contaminated media, most of the feeding relationships ultimately lead to predatory vertebrates, and terrestrial and aquatic components are interconnected.

The predators most susceptible to the effects of bioaccumulation are the vertebrates that feed on aquatic organisms. This includes the piscivorous birds such as the great blue heron, black-crowned night heron, and the double-crested cormorant (Figure 4-2, Table 4-1). The only mammalian predator that feeds extensively in aquatic habitats is the raccoon. The top avian predators in the terrestrial ecosystem are raptors such as the red-tailed hawk, American kestrel, northern harrier, and great horned owl (Figure 4-3, Table 4-1). The bald eagle, ferruginous hawk, and peregrine falcon also may be important because they are protected by federal regulations. However, the habitat and prey resources at RFETS are not well suited for these species. Because the coyote is at the top of the mammalian food chain and is common in the area, it is the most important mammalian predator in terrestrial systems.

4.2.5 Other Factors Affecting Exposure Frequency and Duration

The magnitude of exposure to environmental contaminants is not only dependent on concentration but also on the frequency and duration of contact with contaminants. For the most part, concentrations of contaminants in soil, sediment, and groundwater are relatively static, and therefore any resulting exposures would be relatively constant for resident species. Concentrations in surface water may change seasonally or with precipitation events, flow levels, or other hydrological factors affecting contaminant transport. The dominant factor controlling the exposure of ecological receptors is the behavior of individuals. Daily, weekly, and seasonal

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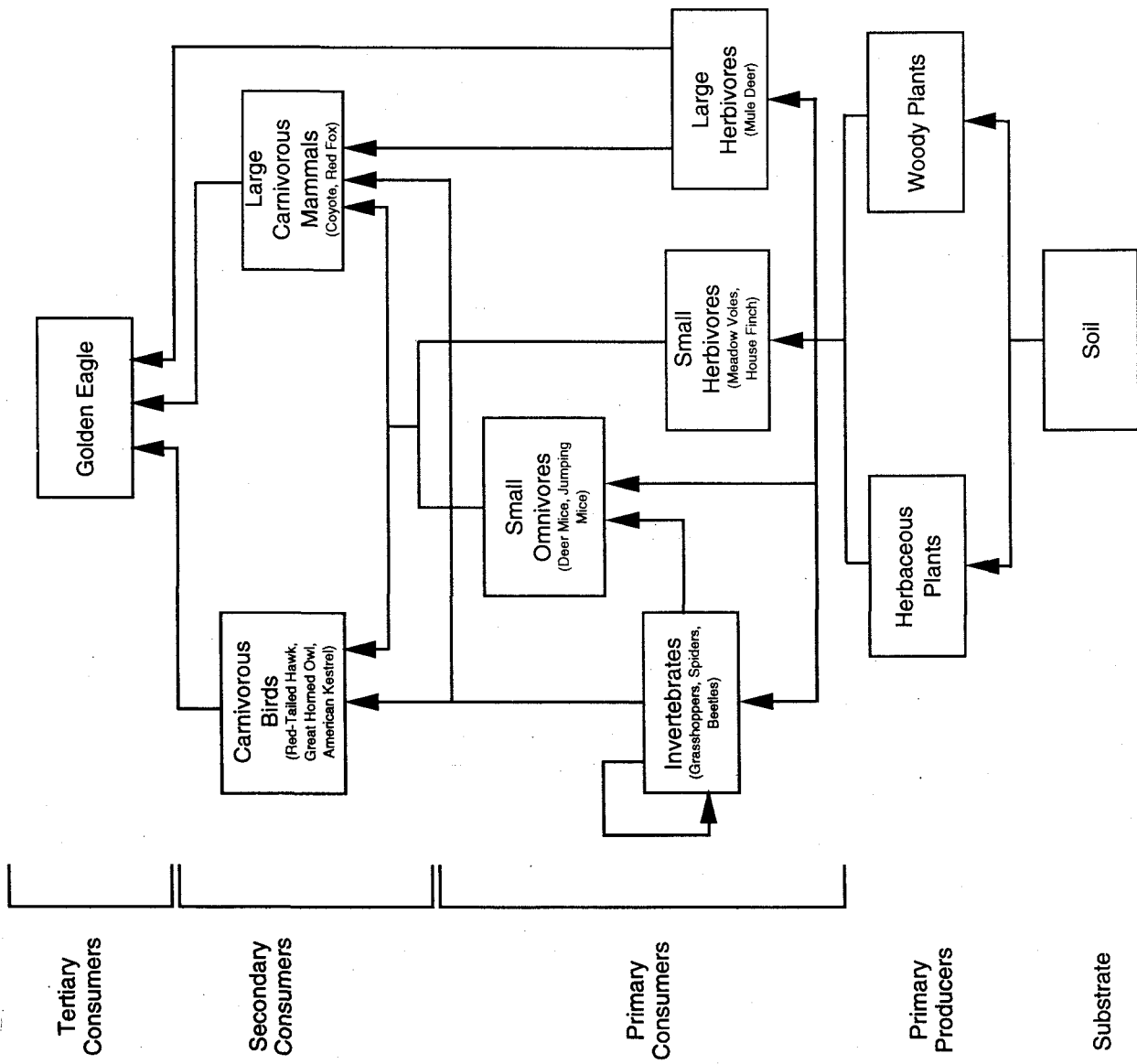
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

Final Draft
Ecological Risk Assessment Methodology
Technical Memorandum No. 2
Situwide Conceptual Model

Generalized Aquatic Food Web

February 1995

Figure 4-2



U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

Final Draft
Ecological Risk Assessment Methodology
Technical Memorandum No. 2
Site-wide Conceptual Model

Generalized Terrestrial Food Web

February 1995

Figure 4-3

G95/EST/terrestrial food web-2501.mdw

Table 4-1
Summary of Common Species in Trophic Levels and Functional Groups
in Aquatic and Terrestrial Food Webs

Functional Group/Species	Primary Producers	Primary Consumers	Secondary Consumers	Tertiary Consumers
Aquatic Food Web				
<i>Autotrophs</i>				
Phytoplankton	X			
Aquatic Macrophytes	X			
<i>Invertebrates</i>				
Zooplankton		X	X	
Benthic Macroinvertebrates		X	X	X
<i>Fishes</i>				
Golden Shiner		X		
White Sucker		X	X	
Creek Chub		X	X	
Fathead Minnow			X	
Green Sunfish		X	X	
Largemouth Bass			X	X
<i>Amphibians</i>				
Tiger Salamander		X	X	
Woodhouse's Toad		X	X	
Chorus Frog		X	X	
Northern Leopard Frog		X	X	
<i>Reptiles</i>				
Garter Snake			X	
<i>Birds</i>				
Great Blue Heron			X	X
Black-Crowned Night-Heron			X	X
Double-Crested Cormorant			X	X
Mallard		X	X	
Gadwall		X	X	
Cliff Swallow			X	
Barn Swallow			X	
Red-Winged blackbird		X	X	
Brown-Headed Cowbird		X	X	
<i>Mammals</i>				
Muskrat		X		
Raccoon		X	X	
Coyote			X	
Terrestrial Food Web				
<i>Autotrophs</i>				
Herbaceous and Woody Vegetation	X			
<i>Invertebrates</i>				
Grasshopper		X		
Soil Invertebrate		X	X	
Spider			X	
<i>Reptiles</i>				
Prairie Rattlesnake			X	
Bullsnake			X	
Yellow-Bellied Racer			X	
Garter Snake			X	

Table 4-1
Summary of Common Species in Trophic Levels and Functional Groups
in Aquatic and Terrestrial Food Webs

Functional Group/Species	Primary Producers	Primary Consumers	Secondary Consumers	Tertiary Consumers
Amphibians				
Plains Spadefoot Toad			X	
Woodhouse's Toad			X	
Birds				
Cliff Swallow			X	
Barn Swallow			X	
House Finch		X		
Western Meadowlark		X	X	
Vesper Sparrow			X	
Grasshopper Sparrow			X	
Song Sparrow			X	
Black-Billed Magpie		X	X	
Gadwall		X		
Mallard		X		
Red-Tailed Hawk			X	X
Northern Harrier			X	
Swainson's Hawk			X	
Ferruginous Hawk*			X	
Golden Eagle			X	X
Bald Eagle*			X	X
American Kestrel			X	
Peregrine Falcon*				X
Prairie Falcon				X
Great Horned owl			X	X
Mammals				
Thirteen-Lined Ground Squirrel		X		
Black-Tailed Prairie Dog		X		
Harvest Mouse		X		
Hispid Pocket Mouse		X		
Plains Pocket Mouse		X		
Silky Pocket Mouse		X		
Deer Mouse		X	X	
Mexican Woodrat		X	X	
Preble's Meadow Jumping Mouse*		X	X	
Meadow Voles		X		
Prairie Vole		X		
Desert Cottontail		X		
Mule Deer		X		
Coyote			X	X
Raccoon		X	X	

* Species of special concern because of rare occurrence and/or legally protected status

use patterns determine the amount of time an animal is in contact with contaminated media. Species such as the deer mouse or meadow vole may remain in a small area for most of its life.

Such species have relatively constant contact with contaminated media and represent a good "worst-case" scenario in evaluating ecological risk. Other more mobile species such as foxes, coyotes, red-tailed hawks, and kestrels use much larger areas that may include uncontaminated areas and may leave RFETS during seasonal migrations. These factors will be considered on a case-by-case basis when estimating exposures to receptors.

5.0 KEY RECEPTOR SPECIES AND EXPOSURE ANALYSIS APPROACH

5.1 Identification of Key Receptors

Because of the great diversity of plants and animals, it is impractical to evaluate exposures for all possible receptors. Therefore, exposures are estimated for a representative group of species, key receptors. A list of candidate species was identified based on their relation to assessment endpoints (EPA 1994), their importance as keystone or indicator species (Krebs 1985, NBS 1994), and life history parameters that made them useful for evaluating risk on spatial scales appropriate to RFETS ERAs. The key receptors actually used in an ERA should be chosen based on criteria listed below. The overall approach to the exposure assessment portion of the ERAs is to estimate exposure for individuals and, for species that are not threatened or endangered, the corresponding effects extrapolated to the population-level effects (Barnhouse 1993).

5.1.1 Criteria for Selection

Candidate species for use as key receptors should be chosen according to the following criteria:

1. The species should (1) be a keystone species in the local ecosystem (Krebs 1985), (2) be representative of a functional group within the feeding guild, (3) occupy a key position in the local food web, (4) be an indicator species (NBS 1994), or (5) be protected under the Endangered Species Act or equivalent state statute.
2. The species home range should include RFETS and have a home range size appropriate for both the area and contaminant of concern.
3. The species or group it represents should be included in at least one complete exposure pathway.
4. The species or group it represents should be susceptible to toxic effects of the contaminant under consideration.
5. Adequate life history data should be available to estimate diet composition, daily dietary intakes, and daily ingestion of water. In addition, information on seasonal habitat use and home ranges is needed to estimate the proportion of food or other resources that may be obtained from the area of concern.

Other factors that should be considered in selecting key receptors include:

- Whether the species represents a bounding exposure scenario for evaluation of the group under consideration
- Whether site populations are sufficient to support tissue sampling (if proposed) and that sampling should be cost-effective
- The sociological importance of the species or its importance to a group with high sociological importance (Suter 1989, 1993)

The key receptor groups and their exposure parameters are listed in Tables 5-1 through 5-13, and the rationale for their selection is summarized below. The routes for which exposure may be estimated are also listed. Candidate species were identified on the basis of information on documented occurrence at RFETS or likelihood of occurrence based on regional wildlife information (DOE 1992a, DOE 1993a, EG&G 1993b). Life history information such as daily dietary and water ingestion rates, diet, and home range size necessary for exposure estimation were taken from the EPA Wildlife Exposure Factors Handbook (EPA 1993) or other sources in primary and secondary scientific literature. These data and their sources are presented in Section 5.3.

5.1.2 Selection of Receptors

5.1.2.1 *Vegetation*

No representative species have been designated for vegetation because little information is available on toxicity to native species of vegetation. Instead, exposure may be evaluated using data on toxic exposures to grassland plants in general. Exposure of vegetation to contaminants should be estimated on the basis of direct exposure to contaminants in soils and/or groundwater. Risk of toxic exposure is evaluated by comparing concentrations of contaminants in soils to concentrations known to result in sub-lethal toxicities. Community-level impacts will be evaluated based on community-level parameters such as species richness, diversity, production, and community composition; results of phytotoxicity tests; or exposure estimates.

5.1.2.2 *Small Mammals*

Mice, voles, and other small rodents are important components of the terrestrial prey base at RFETS (DOE 1992a). The deer mouse, meadow vole, and prairie vole were selected to represent this group. They were chosen because they are ubiquitous at the site and are major prey sources for avian and mammalian predators. Prairie dogs may also be important in prey base. However, they do not generally occur in the source areas and are, in general, relatively rare at RFETS. Data on mice and voles from source areas and background areas will be used to estimate exposure for carnivores that may feed on prairie dogs.

Mice and voles may be assessed both for exposure to contaminants and as exposure points for predators. Their home ranges are such that individuals captured within most source areas are likely to have spent most of their lives there. Exposure of these species is evaluated by estimating contaminant uptake through ingestion of vegetation and terrestrial arthropods. Mice and voles obtain water primarily from condensation on vegetation (dew) and from metabolic production of water from food. Therefore, exposure to contaminants in surface water is not a potentially complete pathway and should not be assessed. Organic contaminants in soil may volatilize and accumulate in animal burrows. Therefore, the potential for exposure to contaminants in burrow air may also be assessed. Specimens of these species were collected for tissue analysis to evaluate the potential for bioaccumulation of metal and radionuclide COCs to toxic levels. These data may be also used to estimate exposures to predators and to evaluate the bioaccumulation of contaminants.

5.1.2.3 *Mule Deer*

Mule deer are widespread at RFETS, are year-round residents, and are the most abundant large herbivore at the site (DOE 1992a). Results of the Rocky Flats Plant Resource Protection Program FY93 Annual Wildlife Survey Report (DOE 1993a) indicate a population of more than 165 deer on the site. Estimates of exposure of mule deer to contaminants are made on the basis of ingestion of vegetation in the OU1 IHSS area and surface water from streams, springs, and ponds. Potential exposure to contaminants is proportional to the amount of time deer spend in a given area and the activities they engage in there. For purposes of exposure assessment, it is assumed that the amount of time deer spend in an area is directly proportional to the fraction of their home range that the area of concern represents.

5.1.2.4 *Coyote*

Coyotes are the most important mammalian predators at RFETS (DOE 1992a). Primary prey include the small mammal species listed above. Coyotes were chosen in part because they are a top predator in the terrestrial food web and there is a resident population at the site. Exposures should be estimated on the basis of ingestion of prey and water. Coyotes are usually born and spend the early part of their lives in burrows. Although it is unlikely that coyotes would use source areas for rearing young, the potential for exposure to volatile contaminants in burrow air may be assessed. As with mule deer, the average home range of coyotes is larger than most source areas. Therefore, exposure estimates are adjusted according to the size of the area under consideration.

5.1.2.5 *Raccoon*

The raccoon is one of the most common omnivores in the United States and is also common at RFETS (DOE 1992a). Nuts, fruits, and other vegetation make up the bulk of their diets (EPA 1993). In addition, raccoons at RFETS have been observed to feed on crayfish and other aquatic invertebrates. Raccoons were included because they have diverse diets and therefore may obtain contaminants from a variety of sources. It is likely that individual raccoons at RFETS visit each of the drainage areas. Therefore, exposure estimations should consider the proportion of time spent in each source area or habitat type.

5.1.2.6 *Red-Tailed Hawk*

The red-tailed hawk is one of the most common hawks in the United States, is a top predator at RFETS, and is a year-round resident (DOE 1992a). Male-female pairs were often observed over the site, and young were successfully reared at a nest along Smart Ditch Creek in the southern part of the Buffer Zone in 1991. The primary prey of red-tailed hawks are small mammals and snakes. Exposure estimates should be made on the basis of ingestion of prey. The foraging range of red-tailed hawks is large and the exposure assessment should be adjusted accordingly.

5.1.2.7 *Great Horned Owl*

The great horned owl is a common avian predator at RFETS (DOE 1992a). The owls are nocturnal predators and feed primarily on small mammals such as voles, deer mice, and rabbits. Exposure of great horned owls to contaminants will be evaluated on the basis of ingestion of

voles and deer mice. Great horned owls were chosen in part because their average home range size is not much larger than many of the source areas.

5.1.2.8 *American Kestrel*

The American kestrel is the most common falcon in open grasslands in North America (EPA 1993). American kestrels are common at RFETS and in surrounding grassland areas. They feed primarily on large invertebrates such as grasshoppers during summer months but depend on small mammals and birds during the rest of the year (EPA 1993). American kestrels were included because they are a common carnivore at RFETS and ingest a variety of prey types. American kestrels are also common prey for red-tailed hawks, great horned owls, and golden eagles. Their home range size can be as small as a few hectares in relatively productive areas, and therefore an individual may obtain the majority of its diet within the drainages at RFETS. American kestrels are present at RFETS year-round. A pair nested successfully in the old Lindsay Ranch house in 1994. However, the subspecies that occurs in Colorado (*F. s. sparverius*) is migratory. Thus, individuals may spend only part of the year feeding at RFETS.

5.1.2.9 *Mallard*

Mallards are a common species of waterfowl throughout North America. Mallards are summer residents of RFETS and feed and breed around the detention ponds along Woman Creek and Walnut Creek. Mallards are omnivores, which feed on aquatic plants, invertebrates, and seeds filtered from sediments in ponds and wetlands. Mallards were chosen to represent "dabbling" ducks that may be exposed to contaminants in pond sediments. Although mallards generally migrate south during winter months, some individuals have been observed on and around the detention ponds throughout the year.

5.1.2.10 *Great Blue Heron*

The great blue heron, a common wading bird throughout North America, has been observed at RFETS. Herons feed primarily on aquatic animals such as fish, crayfish, amphibians, and insects. Because they may feed on carnivorous fish species, herons may represent tertiary consumers in some of the ponds at RFETS. This is important in evaluating the potential for bioaccumulation and ecotoxic effects of organic contaminants of aquatic systems.

5.2 Species of Special Concern

5.2.1 Bald Eagle

Occurrence of the bald eagle at RFETS is rare. However, a pair attempted to nest a few miles east of the site in 1992, 1993, and 1994. Fish are the preferred prey of bald eagles, but they are known to consume ducks, prairie dogs, and carrion. Although its occurrence is rare at RFETS, the bald eagle is federally listed as endangered (and proposed for downlisting to threatened); therefore, risks due to ingestion of prey from the OU1 area were evaluated. Prey resources for eagles were essentially lacking in OU1, and only a qualitative assessment of potential impacts to habitat quality was included in the risk characterization.

5.2.2 Preble's Meadow Jumping Mouse

Preble's meadow jumping mouse is a federal Category 2 species currently being considered for protection (Section 2.2.5). This subspecies of the meadow jumping mouse has been identified from the Rock Creek, Walnut Creek, and Woman Creek drainages. Exposure of this subspecies will be estimated from ingested vegetation and terrestrial arthropods.

5.3 General Exposure Parameters for Potential Key Receptor Species

As noted in Section 4.0, risk from chemical stressors is usually assessed by evaluating exposure and toxicity to individual organisms, then extrapolating to estimate effects to populations or communities. A key component of exposure assessment is estimating the dose of a chemical that a receptor is likely to experience at a given site. In the context of ecotoxicology, dose is defined as the amount of a given substance that enters the body of a receptor (Moriarty 1993, Rand and Petrocelli 1985, Suter 1993). Dose is controlled by factors that affect (1) the frequency and duration of contact with a chemical; (2) the amount of chemical taken up while in contact; and (3) the rate at which a toxicant is sequestered, detoxified, and/or eliminated from the body. Thus, realistic estimation of exposure requires not only data on chemical concentrations at a site but also knowledge of species-specific behaviors that affect frequency and duration of contact and physiological factors that affect the rate at which a chemical is taken up and eliminated. This section describes assumptions about behavioral and physiological factors that will be used in estimating exposures to the key receptors identified in Sections 5.1 and 5.2. Information on parameters that may be used in extrapolating to population and community effects are also presented.

Seven behavioral and physiological parameters were identified for use in exposure estimations:

- Behavioral Factors: home range size, habitat use, diet, seasonal use patterns
- Physiological Factors: food ingestion rate, water ingestion rate, body weight

Many animals exhibit behavior patterns that change with season. For purposes of this document, seasonal use pattern refers only to behaviors such as migration or hibernation that significantly affect the time a species spends at RFETS or in contact with contaminated media. Population density estimates are provided to aid in assessing potential risks to local populations or communities. Some of the key receptor species were selected because they are protected by federal or state statutes. Protected status is important in determining whether overall risk should be evaluated for individuals or populations.

Values for the above parameters were taken from the Wildlife Exposure Factors Handbook (EPA 1993) except where specific information was available from studies conducted at RFETS; in Colorado or Wyoming; or in habitats similar to those found at RFETS. The parameters and the methods for estimating them were also developed based on these documents and the Systems Engineering Analysis Risk Assessment Methodology (SEA RAM) (EG&G 1994b). The information presented here represents the best available data for the site and the most versatile form for use in CERCLA-associated ERAs. Many of the parameters are known to vary with habitat quality and geographic location. In most cases, the original literature source was reviewed to ensure accuracy and applicability of parameter values. The amounts and quality of available information varied among the selected species. When multiple values were available, the median was used as the exposure parameter.

Empirical data on food and water ingestion rates were used wherever reliable information was available. When empirical data were not available, these parameters were estimated using allometric equations based on body size and field metabolic requirements (Calder and Braun 1983, Nagy 1987, EPA 1993). Food ingestion rates were estimated using methods of Nagy (1987) as cited in EPA (1993):

Birds (non-passerine):

Eq. 5-1

$$\text{birds (non-passerine) (g/day)} = 0.301 * (BW_g)^{0.751}$$

Mammals:

Eq. 5-2

$$\text{rodents (g/day)} = 0.0621 * (BW_g)^{0.564}$$

Eq. 5-3

$$\text{all mammals (g/day)} = 0.235 * (BW_g)^{0.822}$$

Food ingestion rates determined from these equations will be reported as dry weight.

Water ingestion rates were estimated using the equations of Calder and Braun (1983).

Birds:

Eq. 5-4

$$\text{water ingestion rate for birds (mL/day)} = 0.059 * (BW_g)^{0.67}$$

Mammals:

Eq. 5-5

$$\text{water ingestion rate for mammals (mL/day)} = 0.099 * (BW_g)^{0.90}$$

Dietary food ingestion rates are reported as wet weight of food, unless otherwise indicated (EPA 1993); the allometric equations are based on dry weight of ingested material (Nagy 1987). Vegetation and small mammal tissues collected for the ERAs were analyzed for contaminant concentration on a fresh weight (wet weight) basis. Wet and dry weights will be reconciled prior to calculation of exposure estimates. For food and water ingestion rate, both grams per day and grams per gram body weight per day are presented in the text. These can be directly applied to calculations of contaminant doses from mass ingested per day or for comparison to no observed adverse effects level (NOAEL), respectively.

5.3.1 Deer Mouse

The deer mouse, a member of the family Muridae and the subfamily Sigmodontinae (Jones *et al.* 1992), is the most widely distributed rodent in North America. Deer mice inhabit virtually all habitats and elevations except wetlands. They are mostly nocturnal and are active year-

round. Primarily granivorous, they also feed on arthropods to varying extents. Deer mice are one of the most well-studied small mammals in North America.

5.3.1.1 Habitat

The deer mouse is ubiquitous in Colorado (Armstrong 1972), where it inhabits grasslands, pinyon-juniper woodlands, semidesert shrublands, montane shrublands, montane forests, subalpine forests, and alpine tundra. It also occurs in riparian communities but is not usually found in wetlands.

5.3.1.2 Body Weight

Body weights for deer mice were taken from the onsite data collected in spring and fall 1993 and 1994 in conjunction with the EcMP. Average weight for 699 females was 18.1 grams; average weight for 708 males was 18.5 g. The average for both sexes was 18.3 grams.

5.3.1.3 Diet Composition

Deer mice have a broad diet that includes seeds, forbs, grasses, and numerous arthropod species. Of the three studies reported in Volume I of EPA (1993), the study by Flake (1973) was selected for use because it was conducted in shortgrass prairie in Colorado and included all four seasons. The following tallies present percent volume of stomach contents by a ranking method (values do not total 100 percent): 43 percent seeds, 5.4 percent forbs, 3.6 percent grasses and sedges, 2.1 percent shrubs, 13 percent beetles, 4.9 percent grasshoppers, 4.9 percent leafhoppers, 9.4 percent Lepidopterans, and 2.0 percent spiders (Flake 1973).

5.3.1.4 Food Ingestion Rate

Numerous studies have been conducted on food ingestion rates by deer mice. The study by Cronin and Bradley (1988, as cited in EPA 1993) was selected because it included both sexes. On a diet of lab chow, nonbreeding adult females ingested 0.19 grams per gram body weight per day, and nonbreeding adult males ingested 0.22 grams per gram body weight per day. The mean for both sexes is 0.21 grams per gram body weight per day. With an assumed mean weight of 18.3 grams, deer mice ingest 3.8 grams of food per day.

5.3.1.5 Water Ingestion Rate

Deer mice consumed 0.19 milliliters (mL) water per gram body weight per day on a diet containing less than 10 percent water and an air temperature of 21 to 24°C (Ross 1930) or on a diet of wheat and peanuts with 10 percent water content and an air temperature of 32 to 34°C (Dice 1922). With an assumed mean weight of 18.3 grams, deer mice consume 3.5 mL of water per day.

5.3.1.6 Home Range

Home range size for deer mice varied from 0.014 hectares in a snowbound subalpine meadow (Cranford 1984, as cited in EPA 1993) to 0.128 hectares in a desert shrubland in Idaho (Bowers and Smith 1979, as cited in EPA 1993). The home range size selected represents a median value and is from a study conducted in ponderosa pine habitat in Oregon. Ponderosa pine occurs in several distinct localities at RFETS and is an adjacent habitat type along the foothills of the Front Range in Colorado. Home ranges are 0.10 hectares for adult males and 0.075 hectares for adult females, with a mean of 0.09 hectares (Bowers and Smith 1979).

5.3.1.7 Population Density

Population density of deer mice is variable and depends on season, habitat, food abundance and availability, predators, and interspecific competition with other small rodents (Armstrong, forthcoming; Merritt and Merritt 1980). Density varied from 0.28 animals per hectare in an Arizona desert study (Brown and Zeng 1989, as cited in EPA 1993) to 49 animals per hectare in an Alaskan spruce-hemlock forest (van Horne 1982). The median value of 2.8 animals per hectare from a Colorado study was selected (Vaughn 1974, cited in EPA 1993).

5.3.1.8 Seasonal Use Pattern

Deer mice are active year-round within their home range.

5.3.1.9 Protected Status

Deer mice do not have any designated special status.

5.3.2 Prairie Vole

The prairie vole is a member of the family Muridae and the subfamily Arvicolinae (Jones *et al.* 1992). Prairie voles dig underground burrows, are active year-round, and are one of the more social species of voles. They form monogamous relationships in social groups made up of the mated pair, their offspring, and unrelated individuals (Fitzgerald *et al.*, forthcoming).

5.3.2.1 Habitat

Prairie voles occur on the central plains of North America in relatively dry areas along stream corridors. In irrigated areas, their distribution is less restricted. Where they overlap with meadow voles, the population densities of the two species tend to be negatively correlated (Klatt 1985 and Krebs 1977, as cited in EPA 1993).

5.3.2.2 Body Weight

Body weights for prairie voles were taken from onsite data collected in spring and fall 1993 and 1994 for the EcMP. Average weight for 77 females was 35.6 grams; average weight for 60 males was 38.4 grams. The average for both sexes was 37.0 grams.

5.3.2.3 Diet Composition

Prairie voles feed on stems, leaves, and the underground parts of a variety of plants including grasses and the bark of trees and shrubs. Arthropods comprised 0 percent of the diet in spring but up to 44 percent of diets in late summer in South Dakota (Agnew *et al.* 1988). Diet composition, presented as percent volume of stomach contents from a field in Kansas, is 54 percent grasses and 46 percent forbs. This study did not show any arthropods in the diet in summer (Fleaharty and Olson 1969, as cited in EPA 1993).

5.3.2.4 Food Ingestion Rate

Food ingestion rate is 0.135 grams per gram body weight per day at 21°C (70° Fahrenheit) on a diet of rolled oats (78 percent) and dried grass (22 percent) (Dice 1922, as cited in EPA 1993). Assuming a body weight of 37.0 grams, the food ingestion rate is 5.0 grams per day.

5.3.2.5 *Water Ingestion Rate*

The water ingestion rate for prairie voles is 0.29 mL per gram body weight per day (Dupre 1983). Assuming a body weight of 37.0 grams, the consumption is 11.0 mL per day.

5.3.2.6 *Home Range*

The median value for home range of prairie voles was selected from the studies presented in EPA (1993). Mean home range for both sexes year-round is 0.03 hectares (Swihart and Slade 1989, as cited in EPA 1993).

5.3.2.7 *Population Density*

Prairie voles are characterized by cyclic fluctuations in population density with a period of two to five years (Krebs and Myers 1974). This variation in time, combined with differences in habitat quality in different locations, results in densities that may vary from a few animals to hundreds of individuals per hectare (Gier 1967). The study by Meserve (1971) was selected for use because data were presented for summer and winter and the habitat was similar to RFETS (xeric prairie). Population density was 21 animals per hectare (Meserve 1971).

5.3.2.8 *Seasonal Use Pattern*

Prairie voles are active year-round within their home range.

5.3.2.9 *Protected Status*

Prairie voles have no designated protected status.

5.3.3 *Meadow Vole*

Meadow voles are in the family Muridae, subfamily Arvicolinae (Jones *et al.* 1992). Meadow voles are the most widely distributed member of the genus *Microtus* in North America. They are large voles known for their invariable association with moist areas and their ability to swim (Johnson and Johnson 1982). They are active throughout the year.

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5.3.1.1 Habitat

On the eastern plains and along the foothills in Colorado, the meadow vole is most common in marshy wetlands along riparian corridors. When found in association with other voles, meadow voles typically occupy the wetter areas.

5.3.3.2 Body Weight

Body weights for meadow voles were taken from onsite data collected in spring and fall 1993 and 1994 for the EcMP. Average weight for 66 males was 38.3 grams; average weight for 59 females was 36.2 grams. The average for both sexes was 37.3 grams.

5.3.3.3 Diet Composition

Diet composition was calculated by combining mean values for each food type across four seasons. Diet composition, as percent volume from stomach contents taken from a tallgrass prairie in Illinois, is 50 percent dicots, 17 percent monocot shoots, 15 percent seeds, 7 percent roots, 8 percent fungi, and 3 percent insects (Lindroth and Batzli 1984).

5.3.3.4 Food Ingestion Rate

The food ingestion rates presented in EPA (1993) for meadow voles are extremely high (0.325 and 0.363 grams per gram body weight per day) compared with the prairie vole (0.135 grams per gram body weight per day) or deer mouse (0.21 grams per gram body weight per day); accounting for body weight, the meadow vole studies (Ognev 1950, as cited in Johnson and Johnson 1982; Dark *et al.* 1983, as cited in EPA 1993) suggest that a meadow vole weighing an average of 6.4 grams more than a prairie vole would consume three times as much food (15.6 and 17.4 grams per day for the two studies, respectively, versus 5.6 grams per day for the prairie vole). The empirically determined ingestion rates for deer mice and prairie voles are similar to calculated values derived from Nagy (1987, as cited in EPA 1993). Therefore, ingestion rates for meadow voles for the exposure assessment are calculated from Nagy (1987) as follows: $0.621 (\text{body mass in grams})^{0.546} = 0.621 (37.3)^{0.564} = 4.78 \text{ grams per day}$ or 0.13 grams dry weight per gram body weight per day.

5.3.3.5 *Water Ingestion Rate*

The water ingestion rate, determined from laboratory conditions (Ernst 1968), is 0.21 mL per gram body weight per day for adult males and females combined. Assuming a body weight of 48.0 grams, water ingestion is 10.1 mL per day.

5.3.3.6 *Home Range*

The median home ranges are extremely variable for meadow voles. The selected median home range size is 0.012 hectares for both sexes in summer (Madison 1980, as cited in EPA 1993).

5.3.3.7 *Population Density*

Population densities of meadow voles are characterized by cyclic fluctuations with a period of two to five years (Krebs and Myers 1974). Densities are extremely variable and range from a few animals per hectare to hundreds of individuals per hectare (Gier 1967). The median density of 94 animals per hectare was selected (Myers and Krebs 1971, as cited in EPA 1993).

5.3.3.8 *Seasonal Use Pattern*

Meadow voles are active year-round within their home range.

5.3.3.9 *Protected Status*

Meadow voles have no designated protected status.

5.3.4 *Preble's Meadow Jumping Mouse*

Preble's meadow jumping mouse is a subspecies of the meadow jumping mouse and a member of the family Zapodidae. Because they are hibernators, jumping mice are active only during spring, summer, and early fall. Preble's meadow jumping mouse is the only subspecies of the meadow jumping mouse in Colorado (Armstrong 1972).

Preble's meadow jumping mouse is a rare mammal with Category 2 candidate status under the federal Endangered Species Act. A petition for listing, pursuant to Section 4(b)(3)(A) of the Endangered Species Act, was filed with the U.S. Department of the Interior on August 9, 1994. At present, RFETS is the only known site with a stable population. Since 1991, the species has

been captured regularly at RFETS in Rock Creek, Walnut Creek, and Woman Creek (including Smart Ditch) drainages.

Little information exists on Preble's meadow jumping mouse (*Z. hudsonius preblei*); therefore, much of the information in this account is for the species as a whole (*Z. hudsonius*). As more information becomes available for Preble's meadow jumping mouse, appropriate adjustments for these exposure parameters will be made.

5.3.4.1 *Habitat*

Meadow jumping mice prefer moist lowland habitats with dense vegetation. They occur in abandoned, grassy fields; in thick vegetation along ponds, streams, and marshes; or in rank herbaceous vegetation of wooded areas. At RFETS, *Z. h. preblei* has been captured in riparian willow shrub communities (EG&G 1992b, 1993d). Other vegetation communities probably are also used, perhaps in a seasonal manner. In one instance, a Preble's meadow jumping mouse was captured from a reclaimed grassland of smooth brome during May.

5.3.4.2 *Body Weight*

The mean body weight to be used in exposure assessments is 19.0 grams. This represents weight of adults prior to fattening for hibernation (Morrison and Ryser 1962).

5.3.4.3 *Diet Composition*

Meadow jumping mice eat seeds, fruit, insects, and fungi. In spring, the diet is 20 percent seeds and 50 percent animal material; as the season progresses, more seeds are eaten. Grass seeds are the dietary mainstay. No percentages were assigned to the different foods presented in the review by Whitaker (1972). For the purposes of the exposure assessment, percentages were assigned as follows: 50 percent grass seeds, 30 percent insects, and 20 percent fruit and fungi (Whitaker 1972).

5.3.4.4 *Food Ingestion Rate*

A daily ingestion rate of dry matter was calculated from Nagy (1987) as follows: $0.621 (\text{body mass in grams})^{0.564} = 0.621 (19.0)^{0.564} = 3.27$ grams dry weight per day. Assuming a weight of 19.0 grams, the ingestion rate is 0.17 grams dry weight per gram body weight per day.

5.3.4.5 *Water Ingestion Rate*

The daily water ingestion rate was calculated from Calder and Braun (1983) as follows: $99 (\text{body mass in kilograms})^{0.9} = 99 (0.019)^{0.9} = 2.79 \text{ mL per day}$. Assuming a body weight of 19.0 grams, the ingestion rate is 0.15 mL per gram body weight per day.

5.3.4.6 *Home Range Size*

The home range sizes of meadow jumping mice at two different sites in Minnesota were 0.17 and 1.1 hectares for males and 0.15 and 0.63 hectares for females (Quimby 1951). In a study in Michigan, home ranges are 0.36 hectares for males and 0.37 hectares for females, with a mean of 0.365 hectare for both sexes. (Blair 1940). The intermediate values found in the Michigan study were selected for use in the exposure assessment.

5.3.4.7 *Population Density*

Population densities of meadow jumping mice are extremely variable (Blair 1940, Quimby 1951). Uncertainty in measurement is exacerbated by their movement patterns. A number of population densities are presented in the literature, ranging from 1.4 animals per hectare in southern Ontario (Boonstra and Hoyle 1986) to 82.9 animals per hectare in Minnesota (Tester *et al.* 1993). Population densities in Colorado, at a distributional limit for the species, can be expected at the low end of the range. A density of 3.22 animals per hectare (Adler *et al.* 1984) represents the low end of the intermediate values and was selected for use in the exposure assessment.

5.3.4.8 *Seasonal Use Pattern*

Preble's meadow jumping mouse has been captured from May through October at RFETS. It is expected to be in hibernation from November through April.

5.3.4.9 *Protected Status*

Preble's meadow jumping mouse is a Category 2 candidate species.

5.3.5 Coyote

The coyote is a widely distributed carnivore in the family Canidae. Coyotes are extreme generalists and have expanded their range in North America since the arrival of European settlers (Bekoff 1977). They are omnivorous in their diet, feeding on both plant and animal material.

5.3.5.1 *Habitat*

Coyotes occur in all habitats, from lowland deserts to alpine tundra. The species is ubiquitous in Colorado (Towry 1987).

5.3.5.2 *Body Weight*

Body weights average 14 kilograms (kg) for males (the median of the range of 8 to 20 kg) and 11.5 kg for females (the median of the range of 7 to 18 kg) (Bekoff 1977). An average weight for both sexes of 12.8 kg is derived from the median values for the two sexes.

5.3.5.3 *Diet Composition*

The coyote diet is dictated by availability. However, 90 percent of the diet is usually animal matter such as rabbits and rodents (mice, voles, and ground squirrels), and 10 percent is plant matter (Bekoff 1977).

5.3.5.4 *Food Ingestion Rate*

Food ingestion rate is about 0.047 grams per gram body weight per day for adults (Gier 1975). Assuming a weight of 12.8 kg, food ingestion is 602 grams per day.

5.3.5.5 *Water Ingestion Rate*

Water ingestion rate was calculated from Calder and Braun (1983) as follows: $99 (\text{body mass in kilograms})^{0.9} = 99 (12.8)^{0.9} = 982 \text{ mL per day}$, or 0.077 mL per gram body weight per day.

5.3.5.6 *Home Range*

Home range size was 11.3 square kilometers (km²) for residents and 106 km² for transients in a population in southeastern Colorado, where 78 percent of individuals were residents and 22 percent were transients (Gese *et al.* 1988). The resident home range size was selected for use in the exposure assessment.

5.3.5.7 *Population Density*

Population density is 0.2 to 0.4 animals per km² over a large portion of their range (Knowlton 1972). One denning pair per km² is estimated as the maximum for the rolling plains of eastern Colorado (Gier 1975) and was selected for use in the exposure assessment.

5.3.5.8 *Seasonal Use Pattern*

Coyotes are active and present year-round.

5.3.5.9 *Protected Status*

Coyotes have no designated protected status.

5.3.6 *Raccoon*

The raccoon is a member of the order Carnivora, family Procyonidae. Raccoons are medium-sized omnivores that have been successful in the presence of human development; in the past 50 years, populations in the United States have increased (Sanderson 1987).

5.3.6.1 *Habitat*

Raccoons occur in wooded areas along streams and lake borders; in mature residential areas; and in irrigated, cultivated, and abandoned farmlands (Burt and Grossenheider 1964, Kaufmann 1982).

5.3.6.2 *Body Weight*

Body weights from west-central Illinois for parous and nulliparous adult females were 6.4 and 6.0 kilograms, respectively; the adult male weight was 7.6 kilograms (Sanderson 1984, as cited in EPA 1993). The average of these weights was 6.9 kilograms.

5.3.6.3 *Diet Composition*

Diet composition varies regionally and seasonally. In a fall study in northeastern Colorado along the South Platte River, the diet was 73 percent plant material, 14 percent animal matter, and 13 percent insects (Tester 1943).

5.3.6.4 *Food Ingestion Rate*

The daily ingestion rate of dry matter, calculated from Nagy (1987), is $0.235 (\text{body mass in grams})^{0.822} = .235 (6,900 \text{ grams})^{0.822} = 336.2 \text{ grams dry weight per day}$ or 0.048 grams dry weight per gram body weight per day.

5.3.6.5 *Water Ingestion Rate*

Water ingestion rate, calculated from Calder and Braun (1983), is $99 (\text{body mass in kilograms})^{0.9} = 99 (6.9)^{0.9} = 563 \text{ mL per day}$. Water intake rate scaled to body weight is 0.08 mL per gram body weight per day.

5.3.6.6 *Home Range*

Home ranges of raccoons are variable. The annual home range of adult males usually encompasses 6.5 square kilometers (Towry 1987). Home range for females is typically less. The value selected for the exposure assessment is 51 hectares, the minimum habitat required for feeding, cover, and space (Towry 1987). Good habitat for raccoons is typically arranged linearly along a riparian corridor.

5.3.6.7 *Population Density*

Population density for raccoons is also variable. The median value of 0.17 animals per hectare was selected (Urban 1970, as cited in EPA 1993).

5.3.6.8 *Seasonal Use Pattern*

Raccoons are active and present year-round.

5.3.6.9 *Protected Status*

Raccoons have no designated protected status.

5.3.7 *Mule Deer*

The mule deer is a medium-sized ungulate in the family Cervidae. Also known as the black-tailed deer, it is widespread throughout western North America. Mule deer feed on both shrubs and herbaceous forage (Hofmann and Stewart 1972).

5.3.7.1 *Habitat*

Mule deer occur in all major habitat types in western North America except desert and tundra (Anderson and Wallmo 1984).

5.3.7.2 *Body Weight*

Adult males are larger than females. Males can attain weights of 70 to 150 kg (Anderson and Wallmo 1984). Average weight for both sexes is 70 kg (Anderson *et al.* 1974).

5.3.7.3 *Diet Composition*

Diet composition over four seasons is 58 percent shrubs, 29 percent forbs, 6 percent grasses, and 7 percent other (Carpenter *et al.* 1979, Kufeld *et al.* 1973).

5.3.7.4 *Food Ingestion Rate*

Mule deer ingest 0.022 grams air-dry forage per gram body weight per day (Alldredge *et al.* 1974). Assuming a weight of 70 kg, the ingestion rate is 1.54 kg per day.

5.3.7.5 *Water Ingestion Rate*

Mule deer in captivity consume 24 to 35 mL of water per kg body weight per day in winter and 47 to 70 mL per kg body weight per day in summer (Bissell *et al.* 1955). The median values for winter and summer were used to calculate an average value of 44 mL per kg body weight per day or 3,080 mL per day assuming a body weight of 70 kg.

5.3.7.6 *Home Range*

Home range size for mule deer, compiled from several studies, is 285 hectares (n=110) (Harestad and Bunnell 1979).

5.3.7.7 *Population Density*

Population density of mule deer, taken from a prairie-woodland riverbreak during winter in Montana, is 3.9 animals per km² (Mackie 1970).

5.3.7.8 *Seasonal Use Pattern*

Xeric mixed grasslands are important feeding areas for mule deer throughout the year and provide the staging ground for rutting behavior. They forage extensively in the south-facing mesic grassland hillsides during winter and spring. Southeast facing slopes below escarpments and the shrublands in the upper portion of Rock Creek are used for shelter during high winds. The shrublands in Rock Creek and Woman Creek are used for fawning. Shrublands are also used for cover during summer, as is tall marshland (DOE 1993a).

5.3.7.9 *Protected Status*

Mule deer have no designated protected status.

5.3.8 Great Blue Heron

The great blue heron is an aquatic, piscivorous species in the order Ciconiiformes and family Ardeidae. Exposure parameters for the great blue heron may be scaled by body mass and used in models for the black-crowned night-heron and the double-crested cormorant, which are other aquatic, piscivorous species found at RFETS.

5.3.8.1 *Habitat*

In the western interior of the United States, great blue herons inhabit freshwater lakes, rivers, and wetlands, particularly where small fish are plentiful in shallow areas (Spendelov and Patton 1988, Short and Cooper 1985, as cited in EPA 1993). They may also forage in wet meadows, pastures, and other terrestrial habitats. They require tall trees for nesting in heronries, usually within close vicinity of foraging grounds.

5.3.8.2 *Body Weight*

Mean weight for both sexes is 2,229 grams (Quinney 1982, as cited in EPA 1993).

5.3.8.3 *Diet Composition*

Diet composition was averaged over two study areas in Michigan, one on a lake and one on a river (Alexander 1977, as cited in EPA 1993). Data are presented as percent wet weight of stomach contents collected in summer: 96 percent fish (74 percent trout and 22 percent non-trout fish), 3.5 percent crustaceans and amphibians, and 0.5 percent birds and mammals.

5.3.8.4 *Food Ingestion Rate*

Food ingestion rate is 0.18 gram per gram body weight per day. It was calculated by EPA (1993) from Kushlan's (1978) allometric equation for wading birds. Assuming a body weight of 2,229 grams, ingestion rate is 401 grams per day.

5.3.8.5 *Water Ingestion Rate*

Water ingestion rate for adult males and females is 0.045 mL per gram body weight per day or 100 mL per day. This rate was estimated by EPA (1993) from Calder and Braun (1983) with body weights from Quinney (1982, as cited in EPA 1993).

5.3.8.6 *Home Range*

Home ranges of great blue herons are difficult to define because foraging distances from the colony may range from 3.1 kilometers to 24.4 kilometers (Dowd and Flake 1985, as cited in EPA 1993). Feeding territories of adults in Oregon are 0.6 hectares in freshwater marshlands

in fall and 8.4 hectares in an estuary in winter (Bayer 1978, as cited in EPA 1993). The average of 4.5 hectares is selected for use in the exposure assessment.

5.3.8.7 Population Density

Population density of great blue herons is 2.3 birds per kilometer (Dowd and Flake 1985, as cited in EPA 1993), as determined from stream habitat in North Dakota.

5.3.8.8 Seasonal Use Pattern

Great blue herons are common in summer and uncommon during spring and fall migration. They are not present during winter (DOE 1993a).

5.3.8.9 Protected Status

Great blue herons have no designated protected status.

5.3.9 Mallard

The mallard is a member of the family Anatidae, order Anseriformes. The mallard forages by dabbling in shallow water and filtering seeds, invertebrates, and other foods from sediments. Males are more colorful than females. Although the mallard is widespread and abundant across the United States, populations have been declining over the past decade due to habitat degradation and drought (USFWS 1991, as cited in EPA 1993).

5.3.9.1 Habitat

Wintering habitat is bottomland wetlands and rivers, as well as reservoirs and ponds (Heitmeyer and Vohs 1984, as cited in EPA 1993). Nesting habitat is dense grassy vegetation with a height of one-half meter or greater (Bellrose 1976, as cited in EPA 1993). Nests usually are located within a few kilometers of water but may be farther away if no suitable areas can be found (Bellrose 1976, Duebbert and Lokemoen 1976, cited in EPA 1993).

5.3.9.2 Body Weight

Body weight averages 1,225 grams for adult males and 1,043 grams for adult females (Nelson and Martin 1953, as cited in EPA 1993), with a mean of 1,134 grams for both sexes.

5.3.9.3 Diet Composition

The diet composition of breeding females in prairie potholes in North Dakota for April, May, and June was 13.8 percent gastropods, 28.9 percent insects, 12.3 percent crustacea, 16.5 percent annelids, 3.2 percent miscellaneous animals, 22.7 percent seeds, 2.2 percent tubers, and 0.4 percent stems (Swanson *et al.* 1985, as cited in EPA 1993). In winter in a Louisiana coastal marsh and prairie, wet volume of esophageal contents was 92.2 percent plants, 1.0 percent snails, and 6.8 percent other (Dillon 1959, as cited in EPA 1993). Both spring and winter diets will be used in the exposure assessment.

5.3.9.4 Food Ingestion Rate

Food ingestion rates were calculated from Nagy (1987). Food ingestion = $0.381 (\text{body weight in grams})^{0.751} = 0.301 (1,134)^{0.751} = 0.301 (196.8) = 59.2$ grams dry weight per day. This is equivalent to 0.052 grams dry weight per gram body weight per day.

5.3.9.5 Water Ingestion Rate

Water ingestion rates, estimated by EPA (1993) from Calder and Braun (1983) with body weights from Nelson and Martin (1953), are 0.058 mL per gram body weight per day for females and 0.055 mL per gram body weight per day for males. This averages to 0.056 mL per gram body weight per day for both sexes, or 63.5 grams per day.

5.3.9.6 Home Range

Home ranges of mallards in Minnesota wetlands and riparian areas in spring were 540 hectares for females and 620 hectares for males (Kirby *et al.* 1985, as cited in EPA 1993). This study was selected because data for males and females were presented. The average home range for both sexes is 580 hectares.

5.3.9.7 Population Density

Population density in North Dakota for both sexes averaged across two different sites was 0.041 pairs per hectare (Lokemoen *et al.* 1990, as cited in EPA 1993).

5.3.9.8 *Seasonal Use Pattern*

Mallards are present year-round (DOE 1993a).

5.3.9.9 *Protected Status*

Mallards have no designated protected status.

5.3.10 *Bald Eagle*

Bald eagles are extremely large raptors in the order Falconiformes, family Accipitridae. They congregate at rich food resources such as fish spawning areas or shallow productive lakes. The bald eagle is a federally listed endangered species.

5.3.10.1 *Habitat*

Bald eagles occur along coastal areas, lakes, and rivers in areas of minimal human activity (Brown and Amadon 1968, Peterson 1986, as cited in EPA 1993). Their habitat is variable and dependent on food supply (Johnsgard 1990). They are winter residents at low elevations in Colorado where they may occur locally in grasslands, especially near prairie dog communities (Andrews and Righter 1992).

5.3.10.2 *Body Weight*

Body weights for bald eagles are 4,123 grams for males and 5,244 grams for females (Johnsgard 1990). As is common in many other raptors, females are larger. The average for both sexes combined is 4,685 grams. The only adult weights listed in EPA (1993) are from Florida, and bald eagle weights vary with latitude (Snow 1973). The larger weights reported in Johnsgard (1990) are more representative of bald eagles at 40° latitude in Colorado.

5.3.10.3 *Diet Composition*

A study on feeding observations at Rocky Mountain Arsenal was selected for use in exposure assessments because of its proximity and similarity of habitat to RFETS. The diet is 52 percent prairie dogs, 17 percent lagomorphs, 6 percent birds, and 24 percent unknown (USFWS 1992). These percentages are based on the number of individual prey items of each taxon; differing weights of prey species will need to be accounted for in the exposure assessment.

5.3.10.4 Food Ingestion Rate

Free-flying adult bald eagles, from a study in Washington, ingested 0.12 grams per gram body weight per day (Stalmaster and Gessaman 1984, as cited in EPA 1993). With an average weight of 4,685, ingestion rate is 562 grams per day.

5.3.10.5 Water Ingestion Rate

Water ingestion rate, calculated by EPA (1993) from Calder and Braun (1983), is 0.036 mL per gram body weight per day averaged for both sexes. With an average body weight of 4,685 grams, water ingestion is 169 mL per day.

5.3.10.6 Home Range

The estimated home range is 1,880 hectares for adults (Griffin and Baskett 1985, as cited in EPA 1993), from a study conducted in the vicinity of a lake in Missouri.

5.3.10.7 Population Density

Population densities are extremely variable outside of the nesting season (Johnsgard 1990). The study site in Yellowstone, Wyoming, was considered to be most similar to RFETS and was selected for use in the exposure parameters. There were 0.035 pairs of eagles per kilometer of freshwater shoreline (Swenson *et al.* 1986, as cited in EPA 1993).

5.3.10.8 Seasonal Use Pattern

Use of RFETS by bald eagles is limited to overflights and occasional perching during fall and winter (DOE 1993a). They are migrants, although nesting has been attempted at Standley Lake.

5.3.10.9 Protected Status

Bald eagles are endangered (USFWS 1994a); a petition has been filed for downlisting them to threatened.

5.3.11 Red-Tailed Hawk

The red-tailed hawk is a member of the family Accipitridae, order Falconiformes. It is the most common hawk in the genus *Buteo* in the United States (National Geographic Society 1987). Red-tailed hawks occur throughout most wooded and semi-wooded areas and on prairie habitats. They nest primarily in woodlands and feed in open country (EPA 1993).

5.3.11.1 Habitat

Red-tailed hawks prefer open areas in a wide range of habitats, including scrub desert, plains and montane grassland, agricultural fields, pastures, urban parklands, broken coniferous and deciduous woodland, and tropical rain forest (Preston and Beane 1993).

5.3.11.2 Body Weight

Body weights were selected from a study in southwestern Idaho. An average of 1,154 grams was found for adult females and 957 grams for adult males (Steenhof 1983, as cited in EPA 1993). The average for both sexes is 1,055 grams.

5.3.11.3 Diet Composition

Dietary composition for red-tailed hawks in summer, from farm and woodlands in Alberta, Canada, averaged 26 percent snowshoe hare, 35 percent ground squirrels, 5 percent voles and mice, 8 percent other mammals, 16 percent waterfowl, 4 percent grouse, and 6 percent other birds (Adamcik *et al.* 1979, as cited in EPA 1993). Values are percent wet weight of prey brought to chicks.

5.3.11.4 Food Ingestion Rate

Food ingestion rate for red-tailed hawks is 0.098 grams per gram body weight per day (Craighead and Craighead 1956, as cited in EPA 1993). Data were averaged over winter (for adult males and females) and summer (data available only for adult males) for animals fed red meat and prey in captivity outdoors in Michigan. With an average weight of 1,055 grams, the ingestion rate is 103 grams per day.

5.3.11.5 Water Ingestion Rate

Water ingestion rates are 0.055 and 0.059 mL per gram body weight per day for females and males, respectively. Values were calculated by EPA (1993) from Calder and Braun (1983). A mean value of 0.057 mL per gram body weight per day, or 60 mL per day, was selected for use in the exposure assessment.

5.3.11.6 Home Range

Home ranges are not presented in EPA 1993 and are taken from other sources. Breeding home ranges are 570 to 730 hectares (Smith and Murphy 1973). Winter home ranges are 162 hectares (Peterson 1979).

5.3.11.7 Population Density

Population densities from open aspen in Colorado are 0.0017 to 0.0050 pairs per hectare (McGovern and McNurney 1986, as cited in EPA 1993). The average is 0.0034 pairs per hectare.

5.3.11.8 Seasonal Use Pattern

Red-tailed hawks are present year-round, although more common in spring, summer, and fall than in winter (DOE 1993a).

5.3.11.9 Protected Status

Red-tailed hawks have no designated protected status.

5.3.12 American Kestrel

The American kestrel is a small falcon in the order Falconiformes and family Falconidae. Also known as the sparrow hawk, it is the most common falcon in open and semi-open areas throughout North America (EPA 1993).

5.3.12.1 Habitat

American kestrels inhabit open deserts, semi-open areas, and edges of groves and cities (Brown and Amadon 1968, National Geographic Society 1987).

5.3.12.2 Body Weight

Body weights from the Imperial Valley in California (Bloom 1973, as cited in EPA 1993) are 115 grams and 132 grams for females in fall and winter, respectively, and 103 grams and 114 grams for males in fall and winter, respectively. The mean is 123 grams for females and 109 grams for males for the two seasons combined. The mean for both sexes is 116 grams.

5.3.12.3 Diet Composition

The following diet composition is taken from a winter study in open areas and woods in California (Meyer and Balgooyen 1987, as cited in EPA 1993). Data were collected as observations of prey captured and are presented in percent wet weight of prey. Diet includes 32.6 percent invertebrates, 31.7 percent mammals, 30.3 percent birds, 1.9 percent reptiles, and 3.5 percent other.

5.3.12.4 Food Ingestion Rate

The food ingestion rate for adults of both sexes is 0.29 grams per gram body weight per day or 33.6 grams per day from a study of free-living animals in northwestern California (Koplin *et al.* 1980, as cited in EPA 1993). Of that total, 0.18 grams per gram body weight per day are from vertebrate prey, and 90.11 grams per gram body weight per day are from invertebrate prey.

5.3.12.5 Water Ingestion Rate

The water ingestion rate, calculated by EPA (1993) from Calder and Braun (1983), is 0.11 mL per gram body weight per day for adult females and 0.12 mL per gram body weight per day for adult males. This averages to 0.11 mL per gram body weight per day or 12.8 mL per day.

5.3.12.6 Home Range

Home range size for American kestrels appears to vary with food abundance. In one study, home ranges varied from 131 to 202 hectares in Michigan and Wyoming, respectively

(Craighead and Craighead 1956, as cited in EPA 1993). Similar home ranges were found at the Rocky Mountain Arsenal, but studies showed that the actual foraging area was much smaller, averaging 38 hectares for a sample of 12 birds (R. Roy, personal communication). Because foraging is the significant element in exposure assessment, this value will be used for the exposure parameter.

5.3.12.7 Population Density

Population density was 0.0035 pairs per hectare in summer in Wyoming and 0.0005 birds per hectare in winter and 0.0010 birds per hectare in spring in southern Michigan (Craighead and Craighead 1956, as cited in EPA 1993). Combining the three seasons and two locations results in a population density of 0.003 birds per hectare, the value selected for use in the exposure assessment.

5.3.12.8 Seasonal Use Pattern

American kestrels breed onsite and are present year-round.

5.3.12.9 Protected Status

American kestrels have no designated protected status.

5.3.13 Great Horned Owl

The great horned owl, in the order Strigiformes and family Strigidae, is a very large owl with ear tufts. Great horned owls are common throughout North America (National Geographic Society 1987) and are relatively tolerant of human activities.

5.3.13.1 Habitat

Great horned owls prefer lowland riparian forests and agricultural areas (Andrews and Righter 1992) and hunt in grasslands and shrublands adjacent to roosting sites. In Colorado, they are frequently found in cottonwood groves of riparian areas.

5.3.13.2 Body Weight

Females are larger than males. Body weight averages 1,304 grams for males and 1,706 grams for females (Craighead and Craighead 1956). The mean for both sexes is 1,505 grams.

5.3.13.3 Diet Composition

According to a Colorado study, diet composition is 14 percent lagomorphs, 70 percent mice and voles, 8.5 percent other rodents, 0.5 percent other mammals, 4.5 percent birds, 0.2 percent fish, and 1.6 percent arthropods (Marti 1974).

5.3.13.4 Food Ingestion Rate

Great horned owls consume about 10.7 percent of their body weight per day in fall and winter and 7.7 percent of their body weight per day in spring and summer with an average of 9.2 percent year-round (Craighead and Craighead 1956). With this percentage, the food ingestion rate for a body weight of 1,505 grams is 138.5 grams per day or 0.092 grams per gram body weight per day.

5.3.13.5 Water Ingestion Rate

Water ingestion rate was calculated from Calder and Braun (1983) as follows: $59 (\text{body mass in kilograms})^{0.67} = 59 (1.505 \text{ kilograms})^{0.67} = 77.6 \text{ mL water consumed per day}$. Consumption per gram body weight is 0.052 mL water per gram body weight per day.

5.3.13.6 Home Range

Feeding ranges were found to be within one-half kilometer of the nest (Baumgartner 1939). Great horned owls occupy a home range throughout the year (Craighead and Craighead 1956).

5.3.13.7 Population Density

Population density averaged one pair per 16 km² in winter and one to three pairs per 1.6 km² year-round (Baumgartner 1939, Craighead and Craighead 1956).

5.3.13.8 Seasonal Use Pattern

Great horned owls are year-round residents.

5.3.13.9 Protected Status

Great horned owls have no designated protected status.

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Table 5-1
Exposure Parameters for the Deer Mouse
(Peromyscus maniculatus)

Parameter	Value and Comments	Reference
Habitat	Ubiquitous in Colorado	Armstrong (1972), Fitzgerald <i>et al.</i> (forthcoming)
Body Weight	18.3 g	EG&G data from EcMP
Diet Composition	seeds 43% forbs 5.4% grasses and sedges 3.6% shrubs 2.1% beetles 13% leafhoppers 4.9% lepidopterans 9.4% spiders 2.0%	Flake (1973)*
Food Ingestion Rate	0.21 g food/g body weight/day	Cronin and Bradley (1988)*
Water Ingestion Rate	0.19 mL water/g body weight/day	Ross (1930)* Dice (1922)*
Home Range	0.09 ha	Browers and Smith (1979)*
Population Density	2.8 animals/ha	Vaughn (1974)*
Seasonal Use Pattern	Year-round	
Protected Status	None	

*Cited in EPA (1993)

Table 5-2
Exposure Parameters for the Prairie Vole
(Microtus ochrogaster)

Parameter	Value and Comments	Reference
Habitat	Inhabits grasslands in Colorado, especially in the vicinity of drainages and irrigated areas	Fitzgerald <i>et al.</i> (forthcoming)
Body Weight	37.0 g	EG&G data from EcMP
Diet Composition	grasses 54% forbs 46%	Fleharty and Olson (1969)*
Food Ingestion Rate	0.135 g food/g body weight/day at 21°C	Dice (1922)*
Water Ingestion Rate	0.29 mL water/g body weight/day	Dupre (1983)*
Home Range	0.03 ha	Swihart and Slade (1989)
Population Density	21 animals/ha	Meserve (1971)
Seasonal Use Pattern	Year-round	
Protected Status	None	

*Cited in EPA (1993)

Table 5-3
Exposure Parameters for the Meadow Vole
(Microtus pennsylvanicus)

Parameter	Value and Comments	Reference
Habitat	Wetlands, permanently moist areas, and riparian communities	Fitzgerald <i>et al.</i> (forthcoming), Armstrong (1972)
Body Weight	37.3 g	EG&G data from EcMP
Diet Composition	dicots 50% monocot shoots 17% seeds 15% roots 7% fungi 8% insects 3%	Lindroth and Batzli (1984)*
Food Ingestion Rate	0.13 g dry weight/g body weight/day	Nagy (1987)*
Water Ingestion Rate	0.21 mL water/g body weight/day	Ernst (1968)*
Home Range	0.012 ha	Madison (1980)*
Population Density	94 animals/ha	Krebs & Meyers (1974)
Seasonal Use Pattern	Year-round	
Protected Status	None	

*Cited in EPA (1993)

Table 5-4
Exposure Parameters for the Preble's Meadow Jumping Mouse
(Zapus hudsonius preblei)

Parameter	Value and Comments	Reference
Habitat	Moist riparian habitats with a well-developed shrub community	EG&G (1992b), EG&G (1993d)
Body Weight	19.0 g	Morrison and Ryser (1962)
Diet Composition	grass seeds 50% insects 30% fruit and fungi 20%	Whitaker (1972)
Food Ingestion Rate	3.27 g per day of dry matter 0.17 g dry matter/g body weight/day	Nagy (1987)*
Water Ingestion Rate	0.15 mL water/g body weight/day	Calder and Braun (1983)*
Home Range	0.365 ha	Blair (1940)
Population Density	3.22 animals/ha	Adler <i>et al.</i> (1984)
Seasonal Use Pattern	Active May–October In hibernation November–April	Whitaker (1972) RFETS data
Protected Status	Category 2 candidate	USFWS (1994)

*Cited in EPA (1993)

Table 5-5
Exposure Parameters for the Coyote
(Canis latrans)

Parameter	Value and Comments	Reference
Habitat	Ubiquitous	Towry (1987)
Body Weight	12.8 kg	Bekoff (1977)
Diet Composition	Animal matter (rabbits and rodents) 90% Plant matter 10%	Bekoff (1977)
Food Ingestion Rate	0.047 g food/g body weight/day for adults	Gier (1975)
Water Ingestion Rate	0.077 mL water/g body weight/day	Calder and Braun (1983)
Home Range	11.3 km ²	Gese <i>et al.</i> (1988)
Population Density	One pair per km ²	Gier (1975)
Seasonal Use Pattern	Active year-round	
Protected Status	None	

Table 5-6
Exposure Parameters for the Raccoon
(Procyon lotor)

Parameter	Value and Comments	Reference
Habitat	Wooded areas along streams and lake borders, mature residential areas, and irrigated cultivated abandoned farmlands	Burt and Grossenheider (1964), Kaufmann (1982)*
Body Weight	6.9 kg	Sanderson (1984)*
Diet Composition	Plant material 73 % Animal matter 14 % Insects 13 %	Tester (1943)
Food Ingestion Rate	0.048 g food/g body weight/day	Nagy (1987)*
Water Ingestion Rate	0.08 mL water/g body weight/day	Calder and Braun (1983)*
Home Range	51 ha minimum individuals may range over 6.5 km ²	Towry (1987)
Population Density	0.17 animals/ha	Urban (1970)*
Seasonal Use Pattern	Year-round	
Protected Status	None	

*Cited in EPA (1993)

Table 5-7
Exposure Parameters for the Mule Deer
(*Odocoileus hemionus*)

Parameter	Value and Comments	Reference
Habitat	All major habitat types except deserts and tundra	Anderson and Wallmo (1984)
Body Weight	70 kg for adults	Anderson <i>et al.</i> (1974)
Diet Composition	shrubs 58% forbs 29% grass 6% other 7%	Carpenter <i>et al.</i> (1979), Kufeld <i>et al.</i> (1973)
Food Ingestion Rate	0.022 g air dry forage/kg body weight/day	Allredge <i>et al.</i> (1974)
Water Ingestion Rate	44 mL water/kg body mass/day	Bissell <i>et al.</i> (1955)
Home Range	285 ha	Harestad and Bunnell (1979)
Population Density	3.9 animals/km ²	Mackie (1970)
Seasonal Use Pattern	Year-round: forage in xeric mixed grassland Winter and spring: forage on south-facing mesic grassland hillsides Periods of high winds in winter: southeast-facing slopes below escarpments and shrublands in upper Rock Creek Spring fawning: shrublands in Rock Creek and Woman Creek Summer: shrublands and tall marsh used for cover Fall rut: xeric mixed grassland	DOE (1993c)
Protected Status	None	

Table 5-8
Exposure Parameters for the Great Blue Heron
(Ardea herodias)

Parameter	Value and Comments	Reference
Habitat	Freshwater lakes, rivers, and wetlands	Spendelow and Patton (1988),* Short and Cooper (1985)*
Body Weight	2,229 g	Quinney (1982)*
Diet Composition	trout 74% non-trout fish 22% crustaceans and amphibians 3.5% birds and mammals 0.5%	Alexander (1977)*
Food Ingestion Rate	0.18 g food/g body weight/day	Estimated by EPA (1993), from Kushlan (1978)
Water Ingestion Rate	0.045 mL water/g body weight/day	Calder and Braun (1987)*
Home Range	4.5 ha	Bayer (1978)*
Population Density	2.3 birds/km along streams	Dowd and Flake (1985)*
Seasonal Use Pattern	Present during summer, migrate in spring and fall	DOE (1993c)
Protected Status	None	

*Cited in EPA (1993)

Table 5-9
Exposure Parameters for the Mallard
(Anas platyrhynchos)

Parameter	Value and Comments	Reference
Habitat	Natural bottomland wetlands and rivers, reservoirs, and ponds in winter. Dense grassy vegetation with height of at least one-half meter, usually within a few kilometers of water, for nesting.	Heitmeyer and Vohs (1984),* Bellrose (1976),* Duebbert and Lokemoen (1976)*
Body Weight	1,134 g	Nelson and Martin (1953)*
Diet Composition	Spring breeding season: invertebrates 74.7% plant material 25.3% Winter: snails 1.0% plant material 92.2% other 6.8%	Dillon (1959),* Swanson <i>et al.</i> (1985)*
Food Ingestion Rate	0.056 g dry weight/g body weight/day	Nagy (1987)*
Water Ingestion Rate	0.052 mL water/g body weight/day	estimated by EPA (1993)
Home Range	580 ha	Kirby <i>et al.</i> (1985)*
Population Density	0.041 pairs/ha	Lokemoen <i>et al.</i> (1990)*
Seasonal Use Pattern	Year-round	DOE (1993c)
Protected Status	None	

*Cited in EPA (1993)

Table 5-10
Exposure Parameters for the Bald Eagle
(Haliaeetus leucocephalus)

Parameter	Value and Comments	Reference
Habitat	Winter resident at low elevations in Colorado where it may occur locally in grasslands, especially near prairie dog towns	Andrews and Righter (1992)
Body Weight	4,685 g	Johnsgard (1990)
Diet Composition ¹	prairie dogs 52% lagomorphs 17% birds 6% unknown 24%	USFWS (1992)
Food Ingestion Rate	0.12 g food/g body weight/day	Stalmaster and Gessaman (1984)*
Water Ingestion Rate	0.036 mL water/g body weight/day	Calder and Braun (1983), estimated by EPA (1993)*
Home Range	1,880 ha	Griffin and Baskett (1985)*
Population Density	Extremely variable outside the nesting season; 0.035 pairs per km of shore	Johnsgard (1990), Swenson <i>et al.</i> (1986)*
Seasonal Use Pattern	Migrant; occasionally present during fall and winter	DOE (1993c)
Protected Status	Endangered ²	USFWS (1993)

¹Percentages based on number of individual prey items.

²Petition has been filed for downlisting to threatened.

*Cited in EPA (1993)

Table 5-11
Exposure Parameters for the Red-Tailed Hawk
(Buteo jamaicensis)

Parameter	Value and Comments	Reference
Habitat	Open areas in a wide range of habitats, including scrub desert, plains and montane grassland, field, urban parklands, broken forest and woodlands, and tropical rain forest	Preston and Beane (1993)
Body Weight	1,055 g	Steenhof (1983)*
Diet Composition	lagomorph 26% ground squirrel 35% voles and mice 5% other mammals 8% waterfowl 16% other birds 10%	Adamcik <i>et al.</i> (1979)
Food Ingestion Rate	0.098 g food/g body weight/day	Craighead and Craighead (1956)*
Water Ingestion Rate	0.057 mL water/g body weight/day	Calder and Braun (1983), calculated by EPA (1993)*
Home Range	Breeding: 570-730 ha Winter: 162 ha	Smith and Murphy (1973), Peterson (1979)
Population Density	0.0034 pairs per ha	McGovern and McNurney (1986)*
Seasonal Use Pattern	Year-round	DOE (1993c)
Protected Status	None	

*Cited in EPA (1993)

Table 5-12
Exposure Parameters for the American Kestrel
(Falco sparverius)

Parameter	Value and Comments	Reference
Habitat	Open and semi-open habitats and urban areas	Brown and Amadon (1968), National Geographic Society (1987)
Body Weight	116 g	Bloom (1973)*
Diet Composition	invertebrates 32.6% mammals 31.7% birds 30.3% reptiles 1.9% other 3.5%	Meyer and Balgooyen (1987)*
Food Ingestion Rate	0.29 g food/g body weight/day	Koplin <i>et al.</i> (1980)*
Water Ingestion Rate	0.11 mL water/g body weight/day	Calder and Braun (1983)*
Home Range	38 ha	Richard Roy, USFWS, RMA (1995 personal communication)
Population Density	0.003 birds per ha	Craighead and Craighead (1956)*
Seasonal Use Pattern	Year-round	DOE (1993c)
Protected Status	None	

*Cited in EPA (1993)

Table 5-13
Exposure Parameters for the Great Horned Owl
(Bubo virginianus)

Parameter	Value and Comments	Reference
Habitat	Lowland riparian forests and agricultural areas, and grasslands and shrublands while hunting	Andrews and Righter (1992)
Body Weight	1,505 g	Craighead and Craighead (1956)
Diet Composition	lagomorphs 14% mice and voles 70% other rodents 8.5% other mammals 0.5% birds 4.5% fish 0.2% arthropods 1.6%	Marti (1974)
Food Ingestion Rate	0.092 g food/g body weight/day	Craighead and Craighead (1956)
Water Ingestion Rate	0.052 mL water/g body weight/day	Calder and Braun (1983)
Home Range	Feeding ranges within 1/2 km of nest	Craighead and Craighead (1956), Baumgartner (1939)
Population Density	One pair per 16 km ² in winter One to three pairs per 1.6 km ² all year	Craighead and Craighead (1956), Baumgartner (1939)
Seasonal Use Pattern	Year-round	DOE (1993c)
Protected Status	None	

5.4 Measurement Endpoints

Existing ecological data for RFETS have been collected during several field sampling events, including RFI/RI investigations, baseline wildlife surveys, and ecological monitoring programs. Each of the studies was designed for specific programmatic objectives and resulted in collection of a variety of data types. Many of the data were collected for OU-specific ERAs associated with sampling objectives and schedules specified in interagency agreements between DOE, EPA, and CDPHE. Data have been collected during different time periods since 1990.

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Appendix A
Walnut Creek Drainage Basin
Potential Contaminants of Concern

Table A-1
Surface Soil PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin¹

Analyte	OU7 ²					
	OU2	OU4	OU6	0-2"	0-10"	OU11
Metals						
Antimony			X			X
Arsenic						X
Beryllium		X		X		
Cadmium		X				
Calcium	X	X	X	X		
Chromium	X		X			
Cobalt			X			
Copper			X	X		X
Iron	X		X			
Lead	X		X			X
Magnesium			X			
Mercury		X	X			
Molybdenum			X			
Nickel			X			
Selenium					X	
Silicon	X	X				
Silver		X	X			X
Sodium		X	X			
Strontium			X			
Vanadium			X			
Zinc			X	X		
Radionuclides						
Americium-241	X	X	X	X	X	X
Cesium-134		X				
Gross alpha	X		X			
Gross beta			X			
Plutonium-239/240	X	X	X	X		X
Radium-226	X			X		
Strontium-89/90	X					
Tritium		X				
Uranium-233/234	X	X				X
Uranium-235	X	X				X
Uranium-238	X	X				X
Semivolatile Organic Compounds						
4,4'-DDT	X					
Aroclor-1254	X	X	X			
Aroclor-1260	X					
Benzo(a)anthracene	X	X				

Table A-1
Surface Soil PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin¹

Analyte	OU2	OU4	OU6	OU7 ²		OU11
				0-2"	0-10"	
Benzo(a)pyrene	X	X				
Benzo(b)fluoranthene	X	X				
Benzo(ghi)perylene	X	X				
Benzo(k)fluoranthene	X	X				
Benzoic acid	X					
Bis(2-ethylhexyl)phthalate	X	X				
Chrysene	X	X				
delta-BHC	X					
Di-n-butylphthalate	X	X				
Fluoranthene	X	X				
Indeno(1,2,3-cd)pyrene	X	X				
Phenanthrene	X	X				
Pyrene	X	X				
Water Quality Parameters						
Nitrate/Nitrite		X		X		X

X = selected as a PCOC

¹These PCOC designations are in draft form and are subject to review and approval by the regulatory agencies.

PCOCs are presented for screening and scoping purposes only.

²OU7 PCOCs are for the area east of the Landfill Pond Dam.

Table A-2
Subsurface Soil PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin¹

Analyte	OU2	OU4	OU6	OU7 ²	OU11
Metals					
Aluminum				X	
Arsenic	X			X	
Barium	X	X	X	X	X
Cadmium	X	X			
Calcium	X	X	X		
Cesium					X
Chromium	X		X		
Cobalt	X				
Copper	X				
Lead	X		X	X	
Lithium		X			
Manganese	X	X			
Mercury	X				X
Potassium		X			
Silver	X				
Sodium		X			
Strontium			X		
Vanadium			X		
Zinc	X	X	X	X	
Radionuclides					
Americium-241	X	X	X		X
Cesium-134		X			
Cesium-137	X	X		X	
Gross alpha	X		X		
Gross beta	X				
Plutonium-239/240	X	X	X		X
Radium-226	X	X			
Radium-228	X				
Strontium-89/90	X	X		X	
Tritium	X	X		X	
Uranium-233/234	X	X	X		X
Uranium-235	X	X	X		X
Uranium-238	X	X	X	X	X
Semivolatile Organic Compounds					
2-Chlorophenol			X		
2-Methylnaphthalene	X				
2-Methylphenol	X				
4,4'-DDT	X				

Table A-2
Subsurface Soil PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin¹

Analyte	OU2	OU4	OU6	OU7 ²	OU11
4-Methylphenol	X				
4-Nitroaniline	X				
Acenaphthene	X		X		
Anthracene	X				
Aroclor-1254	X				
Benzo(a)anthracene	X		X	X	
Benzo(a)pyrene	X		X		
Benzo(b)fluoranthene	X		X		
Benzo(ghi)perylene	X				
Benzo(k)fluoranthene			X		
Benzoic acid	X		X		
Bis(2-ethylhexyl)phthalate	X	X	X	X	X
Butyl benzyl phthalate	X			X	
Chrysene	X		X	X	
Di-n-butyl phthalate	X	X			X
Di-n-octyl phthalate	X		X		
Diethyl phthalate			X		X
Dimethyl phthalate					X
Fluoranthene	X		X	X	
Fluorene	X				
Hexachloroethane	X				
Hexochlorobutadiene	X				
Indeno(1,2,3-cd)pyrene	X		X		
N-Nitrosodiphenylamine	X				
Naphthalene	X				
Pentachlorophenol	X		X		
Phenanthrene	X		X	X	
Phenol			X		
Pyrene	X		X	X	
Volatile Organic Compounds					
1,1,1-Trichloroethane	X			X	
1,1,2,2-Tetrachloroethane	X				
1,2-Dichloroethane	X				
1,2-Dichloroethene	X				
1,3-Dichloropropene, cis	X				
1,4-Dichlorobenzene	X		X		
2-Butanone	X	X	X		X
2-Chloroethyl vinyl ether	X				
4-Methyl-2-pentanone	X		X	X	
Acetone	X	X	X		X

Table A-2
Subsurface Soil PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin¹

Analyte	OU2	OU4	OU6	OU7 ²	OU11
Benzene	X		X		
Carbon disulfide	X				
Carbon tetrachloride	X				
Chlorobenzene			X		
Chloroethane	X				
Chloroform	X	X	X		
Ethylbenzene	X				
Methylene chloride	X	X	X		X
Styrene	X		X		
Tetrachloroethene	X				
Toluene	X	X	X	X	X
Total xylenes	X		X	X	
Trichloroethene	X		X		X
Water Quality Parameters					
Cyanide		X			
Nitrate	X				
Nitrate/Nitrite		X			
Sulfide		X			

X = selected as a PCOC

¹These PCOC designations are in draft form and are subject to review and approval by the regulatory agencies. PCOCs are presented for screening and scoping purposes only.

²OU7 PCOCs are for the area east of the Landfill Pond Dam.

Table A-3
Groundwater PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin^{1,2}

				OU7 ³		
Analyte	OU2	OU4	OU6	UHSU Total	LHSU Total	OU11 UHSU
Metals						
Aluminum	X		X			X
Antimony	X		X	X		
Arsenic	X		X			X
Barium	X		X		X	X
Beryllium	X		X			X
Cadmium	X		X			
Calcium	X		X	X	X	
Chromium	X		X		X	X
Cobalt	X		X			X
Copper	X		X			X
Iron	X		X			X
Lead	X		X			X
Lithium	X		X	X		
Magnesium	X		X	X	X	
Manganese	X		X			X
Mercury	X		X			X
Molybdenum	X					
Nickel	X		X		X	X
Potassium	X		X	X		X
Selenium	X		X		X	
Silicon	X		X			
Silver	X		X			
Sodium	X		X	X	X	
Strontium	X		X	X	X	
Tin	X					X
Vanadium	X		X			X
Zinc	X		X			X
Radionuclides						
Americium-241	X		X			X
Cesium-137	X		X			
Gross alpha						X
Gross beta						X
Plutonium-239/240	X		X			X
Radium-226			X			
Strontium-89/90	X		X			
Tritium						X
Uranium-233/234				X		
Uranium-235				X		
Uranium-238				X		

Table A-3
Groundwater PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin^{1,2}

Analyte	OU2	OU4	OU6	OU7 ³		OU11 UHSU
				UHSU Total	LHSU Total	
Semivolatile Organic Compounds						
1,2,3-Trichlorobenzene	X					
1,2,4-Trichlorobenzene	X					
1,2,4-Trimethylbenzene	X		X			
1,3,5-Trimethylbenzene	X					
1,3-Dichlorobenzene	X					
1,4-Dichlorobenzene	X					
Benzoic Acid	X					
Bis(2-ethylhexyl)phthalate	X		X			X
Di-n-butyl phthalate	X					
Diethyl phthalate	X		X			X
Heptachlor epoxide	X					
Hexachlorobutadiene	X					
n-Butylbenzene	X					
Naphthalene	X					
p-Cymene	X					
sec-Butylbenzene	X					
tert-Butylbenzene	X					
Volatile Organic Compounds						
1,1,1,2-Tetrachloroethane	X					
1,1,1-Trichloroethane	X		X			
1,1,2,2-Tetrachloroethane	X					
1,1,2-Trichloroethane	X					
1,1-Dichloroethane	X		X			
1,1-Dichloroethene	X		X			
1,1-Dichloropropene	X					
1,2,3-Trichloropropane	X					
1,2-Dibromo-3-chloropropane	X					
1,2-Dibromoethane	X					
1,2-Dichloroethane	X		X			
1,2-Dichloroethene	X		X			
1,2-Dichloropropane	X					
1,3-Dichloropropane	X					
1,3-Dichloropropene, cis	X					
1,3-Dichloropropene, trans	X					
2-Butanone			X			X
2-Hexanone	X		X			
4-Methyl-2-pentanone	X		X			
Acetone	X		X		X	X
Benzene	X		X	X		X

Table A-3
Groundwater PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin^{1,2}

Analyte	OU2	OU4	OU6	OU7 ³		OU11 UHSU
				UHSU Total	LHSU Total	
Bromobenzene	X					
Bromochloromethane	X					
Bromodichloromethane	X					
Bromoform	X					
Bromomethane	X					
Carbon disulfide	X		X			X
Carbon tetrachloride	X		X			X
Chlorobenzene	X				X	
Chloroethane	X					
Chloroform	X		X			
Chloromethane	X		X			
cis-1,2-Dichloroethene	X		X			
Dibromochloromethane	X					
Dibromomethane	X					
Dichlorodifluoromethane	X					
Ethylbenzene	X		X			
m+p Xylene	X					
m-Xylene	X					
Methylene chloride	X		X	X	X	X
o-Chlorotoluene	X					
o-Xylene	X					
p-Chlorotoluene	X					
p-Xylene	X					
Styrene	X		X			
Tetrachloroethene	X		X			X
Toluene	X		X	X	X	X
Total xylenes	X		X		X	
trans-1,2-Dichloroethene	X		X			
Trichloroethene	X		X			
Trichlorofluoromethane	X					
Vinyl chloride	X		X			
Water Quality Parameters						
Nitrate/Nitrite	X			X		X

X = selected as a PCOC

UHSU = Upper Hydrostratigraphic Unit

LHSU = Lower Hydrostratigraphic Unit

¹These PCOC designations are in draft form and are subject to review and approval by the regulatory agencies.

PCOCs are presented for screening and scoping purposes only.

²No PCOC determinations are currently available for OU4 groundwater.

³OU7 PCOCs are for the area east of the Landfill Pond Dam.

Table A-4
Surface Water PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin^{1,2}

Analyte	OU2 ³	OU4	OU6	OU7 ³	OU11 ³
Metals					
Magnesium			X		
Potassium			X		
Sodium			X		
Radionuclides					
Gross beta			X		
Uranium-233/234			X		
Uranium-235			X		
Uranium-238			X		
Semivolatile Organic Compounds					
Di-n-butyl phthalate			X		
Volatile Organic Compounds					
1,2-Dichloroethane			X		
1,2-Dichloroethene			X		
Acetone			X		
Chloroform			X		
Methylene chloride			X		
Tetrachloroethene			X		
Trichloroethene			X		

X = selected as a PCOC

¹These PCOC designations are in draft form and are subject to review and approval by the regulatory agencies. PCOCs are presented for screening and scoping purposes only.

²No PCOC determinations are currently available for OU4 surface water.

³Surface water is not present in OU2, OU7, or OU11.

Table A-5
Sediment PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin^{1,2}

Analyte	OU2 ³	OU4	OU6 ³ Stream	Pond	OU7 ³	OU11 ³
Metals						
Antimony				X		
Arsenic			X			
Barium			X			
Calcium			X			
Chromium				X		
Cobalt			X	X		
Copper				X		
Iron			X	X		
Magnesium			X	X		
Manganese			X	X		
Potassium			X	X		
Silver				X		
Sodium				X		
Strontium			X			
Vanadium			X	X		
Zinc			X	X		
Radionuclides						
Americium-241			X	X		
Gross alpha				X		
Gross beta				X		
Plutonium-239/240			X	X		
Radium-226				X		
Radium-228				X		
Strontium-89/90				X		
Tritium			X			
Uranium-233/234				X		
Uranium-235				X		
Uranium-238				X		
Semivolatile Organic Compounds						
1,2,4-Trichlorobenzene				X		
2-Methylnaphthalene				X		
Acenaphthene			X	X		
Aldrin				X		
Anthracene			X	X		
Aroclor-1254				X		
Aroclor-1260				X		
Benzo(a)anthracene			X	X		

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Table A-5
Sediment PCOCs Present in Each Operable Unit
Walnut Creek Drainage Basin^{1,2}

Analyte	OU2 ³	OU4	OU6 ³		OU7 ³	OU11 ³
			Stream	Pond		
Benzo(a)pyrene			X	X		
Benzo(b)fluoranthene			X	X		
Benzo(ghi)perylene			X	X		
Benzo(k)fluoranthene			X	X		
Benzoic acid			X	X		
Benzyl alcohol			X			
Bis(2-ethylhexyl)phthalate			X	X		
Butyl benzyl phthalate			X	X		
Chrysene			X	X		
Di-n-butyl phthalate			X			
Di-n-octyl phthalate				X		
Dibenzo(a,h)anthracene				X		
Dibenzofuran			X	X		
Fluoranthene			X	X		
Fluorene			X	X		
gamma-BHC (Lindane)				X		
Heptachlor				X		
Indeno(1,2,3-cd)pyrene			X	X		
Naphthalene			X	X		
Phenanthrene			X	X		
Phenol				X		
Pyrene			X	X		
Volatile Organic Compounds						
2-Butanone				X		
4-Methyl-2-pentanone				X		
Acetone			X	X		
Benzene				X		
Methylene chloride			X	X		
Toluene				X		

X = selected as a PCOC

¹These PCOC designations are in draft form and are subject to review and approval by the regulatory agencies.
PCOCs are presented for screening and scoping purposes only.

²No PCOC determinations are currently available for OU 4 sediment.

³Sediment is not present in OU2, OU7, or OU11.

Appendix B

Woman Creek Drainage Basin Potential Contaminants of Concern

Table B-1
Surface Soil PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2	OU5	OU11
Metals				
Antimony			X	X
Arsenic				X
Cadmium			X	
Calcium		X	X	
Chromium		X		
Cobalt			X	
Copper			X	X
Iron		X		
Lead		X	X	X
Mercury			X	
Silicon		X		
Silver			X	X
Zinc			X	
Radionuclides				
Americium	X			
Americium-241		X	X	X
Gross alpha		X	X	
Gross beta			X	
Plutonium	X			
Plutonium-239/240		X	X	X
Radium-226		X		
Strontium-89/90		X		
Uranium	X			
Uranium-233/234		X	X	X
Uranium-235		X	X	X
Uranium-238		X	X	X
Semivolatile Organic Compounds				
2-Methylnaphthalene			X	
4,4'-DDT		X	X	
Acenaphthene			X	
Acenaphthylene			X	
Aldrin			X	
Anthracene			X	
Aroclor-1248	X			
Aroclor-1254	X	X	X	
Aroclor-1260		X		
Benzo(a)anthracene		X	X	

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Table B-1
Surface Soil PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2	OU5	OU11
Benzo(a)pyrene		X	X	
Benzo(b)fluoranthene		X	X	
Benzo(ghi)perylene		X	X	
Benzo(k)fluoranthene		X	X	
Benzoic acid		X	X	
Bis(2-ethylhexyl)phthalate		X	X	
Butyl benzyl phthalate			X	
Chrysene		X	X	
delta-BHC		X		
Di-n-butyl phthalate		X	X	
Di-n-octyl phthalate			X	
Dibenzo(a,h)anthracene			X	
Dibenzofuran			X	
Dieldrin			X	
Endosulfan sulfate			X	
Endrin ketone			X	
Fluoranthene		X	X	
Fluorene			X	
Heptachlor epoxide			X	
Indeno(1,2,3-cd)pyrene		X	X	
Isophorone			X	
Methoxychlor			X	
Naphthalene			X	
PAHs ³	X			
Phenanthrene		X	X	
Pyrene		X	X	
Water Quality Parameters				
Nitrate/Nitrite				X
Specific Conductivity			X	
Total Organic Carbon			X	

X = selected as a PCOC

¹These PCOC designations are in draft form and are subject to review and approval by the regulatory agencies. PCOCs are presented for screening and scoping purposes only.

²OU1 PCOCs were selected prior to the development of the Gilbert methodology and therefore different statistical tests were used.

³The PAH class of compounds was designated as a PCOC for OU1. However, individual PAH PCOCs were not identified.

Table B-2
Subsurface Soil PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2	OU5	OU11
Metals				
Antimony			X	
Arsenic		X	X	
Barium		X	X	X
Beryllium			X	
Cadmium		X	X	
Calcium		X	X	
Cesium				X
Chromium		X	X	
Cobalt		X	X	
Copper		X	X	
Iron			X	
Lead		X	X	
Manganese		X	X	
Mercury		X		X
Molybdenum			X	
Nickel			X	
Potassium			X	
Silver		X	X	
Sodium			X	
Strontium			X	
Thallium			X	
Zinc		X	X	
Radionuclides				
Americium	X			
Americium-241		X	X	X
Cesium-137		X		
Gross alpha		X	X	
Gross beta		X	X	
Plutonium	X			
Plutonium-239/240		X	X	X
Radium-226		X		
Radium-228		X		
Strontium-89/90		X		
Tritium		X		
Uranium	X			
Uranium-233/234		X	X	X
Uranium-235		X	X	X
Uranium-238		X	X	X

Table B-2
Subsurface Soil PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2	OU5	OU11
Semivolatile Organic Compounds				
1,4-Dichlorobenzene		X		
2-Methylnaphthalene		X	X	
2-Methylphenol		X		
4,4'-DDT		X		
4-Methylphenol		X		
4-Nitroaniline		X		
Acenaphthene		X	X	
Acenaphthylene			X	
alpha-BHC			X	
Anthracene		X	X	
Aroclor-1254		X	X	
Aroclor-1260			X	
Benzo(a)anthracene		X	X	
Benzo(a)pyrene		X	X	
Benzo(b)fluoranthene		X	X	
Benzo(ghi)perylene		X	X	
Benzo(k)fluoranthene			X	
Benzoic acid		X	X	
Bis(2-ethylhexyl)phthalate		X	X	X
Butyl benzyl phthalate		X	X	
Chrysene		X	X	
Di-n-butyl phthalate		X	X	X
Di-n-octyl phthalate		X		
Dibenzo(a,h)anthracene			X	
Dibenzofuran			X	
Diethyl phthalate				X
Dimethyl phthalate				X
Fluoranthene		X	X	
Fluorene		X	X	
Heptachlor epoxide			X	
Hexachloroethane		X		
Hexachlorobutadiene		X		
Indeno(1,2,3-cd)pyrene		X	X	
Isophorone			X	
N-Nitrosodiphenylamine		X		
Naphthalene		X	X	
PAH ³				
Pentachlorophenol		X	X	
Phenanthrene		X	X	

Table B-2
Subsurface Soil PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2	OU5	OU11
Phenol			X	
Pyrene		X	X	
Volatile Organic Compounds				
1,1,2,2-Tetrachloroethane		X		
1,1,1-Trichloroethane	X	X	X	
1,1-Dichloroethene	X			
1,2-Dichloroethane	X	X		
1,2-Dichloroethene		X		
1,3-Dichloropropene, cis		X		
2-Butanone		X	X	X
2-Chloroethyl vinyl ether		X		
4-Methyl-2-pentanone		X	X	
Acetone		X	X	X
Benzene		X		
Carbon disulfide		X		
Carbon tetrachloride	X	X		
Chloroethane		X		
Chloroform	X	X		
Ethylbenzene		X	X	
Methylene chloride		X	X	X
Styrene		X		
Tetrachloroethene	X	X	X	
Toluene	X	X	X	X
Total xylenes	X	X	X	
Trichloroethene	X	X	X	X
Water Quality Parameters				
Nitrate		X		

X = selected as a PCOC

¹These PCOC designations are in draft form and are subject to review and approval by the regulatory agencies. PCOCs are presented for screening and scoping purposes only.

²OU1 PCOCs were selected prior to the development of the Gilbert methodology and therefore different statistical tests were used.

³The PAH class of compounds was designated as a PCOC for OU1. However, individual PAH PCOCs were not identified.

Table B-3
Groundwater PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2	OU5	OU11
Metals				
Aluminum		X	X	X
Antimony		X	X	
Arsenic		X	X	X
Barium		X	X	X
Beryllium		X	X	X
Cadmium		X	X	
Calcium		X	X	
Cesium			X	
Chromium		X	X	X
Cobalt		X	X	X
Copper		X	X	X
Iron		X	X	X
Lead		X	X	X
Lithium		X	X	
Magnesium		X	X	
Manganese		X	X	X
Mercury		X	X	X
Molybdenum		X	X	
Nickel		X	X	X
Potassium		X	X	X
Selenium	X	X	X	
Silicon		X	X	
Silver		X	X	
Sodium		X	X	
Strontium		X	X	
Tin		X	X	X
Vanadium	X	X	X	X
Zinc		X	X	X
Radionuclides				
Americium-241		X	X	X
Cesium-137		X	X	
Gross alpha			X	X
Gross beta			X	X
Plutonium-238			X	
Plutonium-239/240		X	X	X
Radium-226			X	
Strontium-89/90		X	X	
Tritium				X
Uranium-233/234			X	
Uranium-235			X	
Uranium-238			X	

Table B-3
Groundwater PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2	OU5	OU11
Semivolatile Organic Compounds				
1,2,3-Trichlorobenzene		X		
1,2,4-Trichlorobenzene		X		
1,2,4-Trimethylbenzene		X		
1,3,5-Trimethylbenzene		X		
1,4-Dichlorobenzene		X		
Acenaphthene			X	
Benzoic Acid		X		
Bis(2-ethylhexyl)phthalate		X	X	X
Di-n-butyl phthalate		X	X	
Diethyl phthalate		X	X	X
Fluoranthene			X	
Fluorene			X	
Heptachlor epoxide		X		
Hexachlorobutadiene		X		
n-Butylbenzene		X		
Naphthalene		X	X	
p-Cymene		X		
Phenanthrene			X	
Pyrene			X	
sec-Butylbenzene		X		
tert-Butylbenzene		X		
Volatile Organic Compounds				
1,1,1,2-Tetrachloroethane		X		
1,1,1-Trichloroethane	X	X		
1,1,2,2-Tetrachloroethane		X		
1,1,2-Trichloroethane	X	X		
1,1-Dichloroethane	X	X		
1,1-Dichloroethene	X	X		
1,1-Dichloropropene		X		
1,2,3-Trichloropropane		X		
1,2-Dibromo-3-chloropropane		X		
1,2-Dibromoethane		X		
1,2-Dichloroethane	X	X		
1,2-Dichloroethene	X	X		
1,2-Dichloropropane		X		
1,3-Dichlorobenzene		X		
1,3-Dichloropropane		X		
1,3-Dichloropropene, cis		X		
1,3-Dichloropropene, trans		X		
2-Butanone				X
2-Hexanone		X		

Table B-3
Groundwater PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2	OU5	OU11
4-Methyl-2-pentanone		X		
Acetone		X		X
Benzene		X		X
Bromobenzene		X		
Bromochloromethane		X		
Bromodichloromethane		X		
Bromoform		X		
Bromomethane		X		
Carbon disulfide		X		X
Carbon tetrachloride	X	X		X
Chlorobenzene		X		
Chloroethane		X		
Chloroform	X	X		
Chloromethane		X		
cis-1,2-Dichloroethene	X	X		
Dibromochloromethane		X		
Dibromomethane		X		
Dichlorodifluoromethane		X		
Ethylbenzene		X		
m+p Xylene		X		
m-Xylene		X		
Methylene chloride		X	X	X
o-Chlorotoluene		X		
o-Xylene		X		
p-Chlorotoluene		X		
p-Xylene		X		
Styrene		X		
Tetrachloroethene	X	X		X
Toluene	X	X		X
Total xylenes	X	X		
trans-1,2-Dichloroethene		X		
Trichloroethene	X	X		
Trichlorofluoromethane		X		
Vinyl chloride		X		
Water Quality Parameters				
Nitrate/Nitrite		X		X

X = selected as a PCOC

¹These PCOC designations are in draft form and are subject to review and approval by the regulatory agencies. PCOCs are presented for screening and scoping purposes only.

²OU1 PCOCs were selected prior to the development of the Gilbert methodology and therefore different statistical tests were used.

Table B-4
Surface Water PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2 ³	OU5		OU11 ³
			Surface	Seep	
Metals					
Arsenic			X		
Barium			X		
Calcium			X		
Lithium			X		
Magnesium			X		
Selenium			X		
Sodium			X		
Strontium			X		
Radionuclides					
Americium	X				
Americium-241			X		
Gross Alpha			X	X	
Gross Beta				X	
Plutonium	X				
Plutonium-239/240			X		
Plutonium-241					
Uranium-233/234			X	X	
Uranium-235				X	
Uranium-238			X	X	
Semivolatile Organic Compounds					
Benzoic acid			X		
Pentachlorophenol			X		
Volatile Organic Compounds					
1,1,1-Trichloroethane	X			X	
1,1-Dichloroethane	X				
1,1-Dichloroethene	X			X	
1,2-Dichloroethane	X				
1,2-Dichloroethene	X			X	
Acetone				X	
Methylene chloride			X		
Tetrachloroethene	X			X	
Toluene	X				
Total xylenes	X				
Trichloroethene	X			X	
Water Quality Parameters					
Carbonate			X		

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Table B-4
Surface Water PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2 ³	OU5		OU11 ³
			Surface	Seep	
Chloride			X		
Dissolved Organic Carbon			X		
Fluoride			X		
Orthophosphate			X	X	
Sulfate			X		
Total Dissolved Solids			X		
Total Organic Carbon			X		

X = selected as a PCOC

¹These PCOC designations are in draft form and are subject to review and approval by the regulatory agencies. PCOCs are presented for screening and scoping purposes only.

²OU1 PCOCs were selected prior to the development of the Gilbert methodology and therefore different statistical tests were used.

³Surface water is not present in OU2 or OU11.

Table B-5
Sediment PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2 ³	Stream	OU5 Seep	Pond	OU11 ³
Metals						
Aluminum					X	
Antimony				X		
Arsenic			X		X	
Barium					X	
Beryllium				X	X	
Cadmium			X			
Calcium					X	
Chromium					X	
Cobalt					X	
Copper			X		X	
Iron					X	
Lead					X	
Lithium					X	
Magnesium					X	
Manganese					X	
Mercury			X	X	X	
Nickel				X	X	
Potassium				X	X	
Selenium			X		X	
Silver			X			
Strontium					X	
Thallium				X		
Vanadium					X	
Zinc			X	X	X	
Radionuclides						
Americium	X					
Americium-241			X		X	
Gross Alpha					X	
Gross Beta				X	X	
Plutonium	X					
Plutonium-239/240			X		X	
Tritium			X			
Uranium-233/234				X	X	
Uranium-235				X	X	
Uranium-238				X	X	
Semivolatile Organic Compounds						
Aroclor-1254	X					

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Table B-5
Sediment PCOCs Present in Each Operable Unit
Woman Creek Drainage Basin¹

Analyte	OU1 ²	OU2 ³	Stream	OU5 Seep	Pond	OU11 ³
Benzo(a)anthracene				X		
Benzo(a)pyrene						
Benzo(b)fluoranthene						
Benzo(ghi)perylene						
Benzo(k)fluoranthene						
Benzoic acid					X	
Bis(2-ethylhexyl)phthalate				X		
Chrysene				X		
Di-n-butyl phthalate					X	
Fluoranthene				X	X	
PAHs ⁴	X					
Phenanthrene				X		
Phenol					X	
Pyrene				X		
Volatile Organic Compounds						
1,1,1-Trichloroethane	X					
Acetone				X		
Methylene chloride				X		
Tetrachloroethene				X		
Toluene	X				X	
Water Quality Parameters						
Total Organic Carbon			X			

X = selected as a PCOC

¹These PCOC designations are in draft form and are subject to review and approval by the regulatory agencies.

PCOCs are presented for screening and scoping purposes only.

²OU1 PCOCs were selected prior to the development of the Gilbert methodology and therefore different statistical tests were used.

³Sediment is not present in OU2 or OU11.

⁴The PAH class of compounds was designated as a PCOC for OU1. However, individual PAH PCOCs were not identified.

Plate 2-10

ERA and EcMP Field Investigation Sample Sites

to be inserted

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Plate 2-1:

Surficial Geology at Rocky Flats
Environmental Technology Site

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Plate 2-2:

**Soil Types at Rocky Flats
Environmental Technology Site**

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Plate 2-3:

**Vegetation Types Identified at Rocky
Flats Environmental Technology Site**

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Plate 2-4:

**Wetlands Identified at Rocky Flats
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Plate 2-5:

**Areas Surveyed for Ute Ladies'
Tresses (*Spiranthes diluvialis*)**

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Plate 2-6:

**Capture Locations and Probable
Range of Preble's Meadow Jumping
Mouse (*Zapus hudsonius preble*)**

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Plate 2-7:

Surface Water Monitoring Locations

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Plate 2-8:
Sediment Sampling Locations

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Plate 2-9:

Monitoring Well Locations

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EXPLANATION

- Drainage Basin Boundary
- Rock Creek Drainage
- Walnut Creek Drainage
- Women Creek Drainage
- Offsite Areas
- Other Streams and Drainages
- Topographic Contours
- Roads
- Industrial Area/Protected Area
- Rocky Flats Environmental Technology Site Boundary
- ◻ Lakes and Ponds
- ◼ Buildings



Scale = 1 : 36000



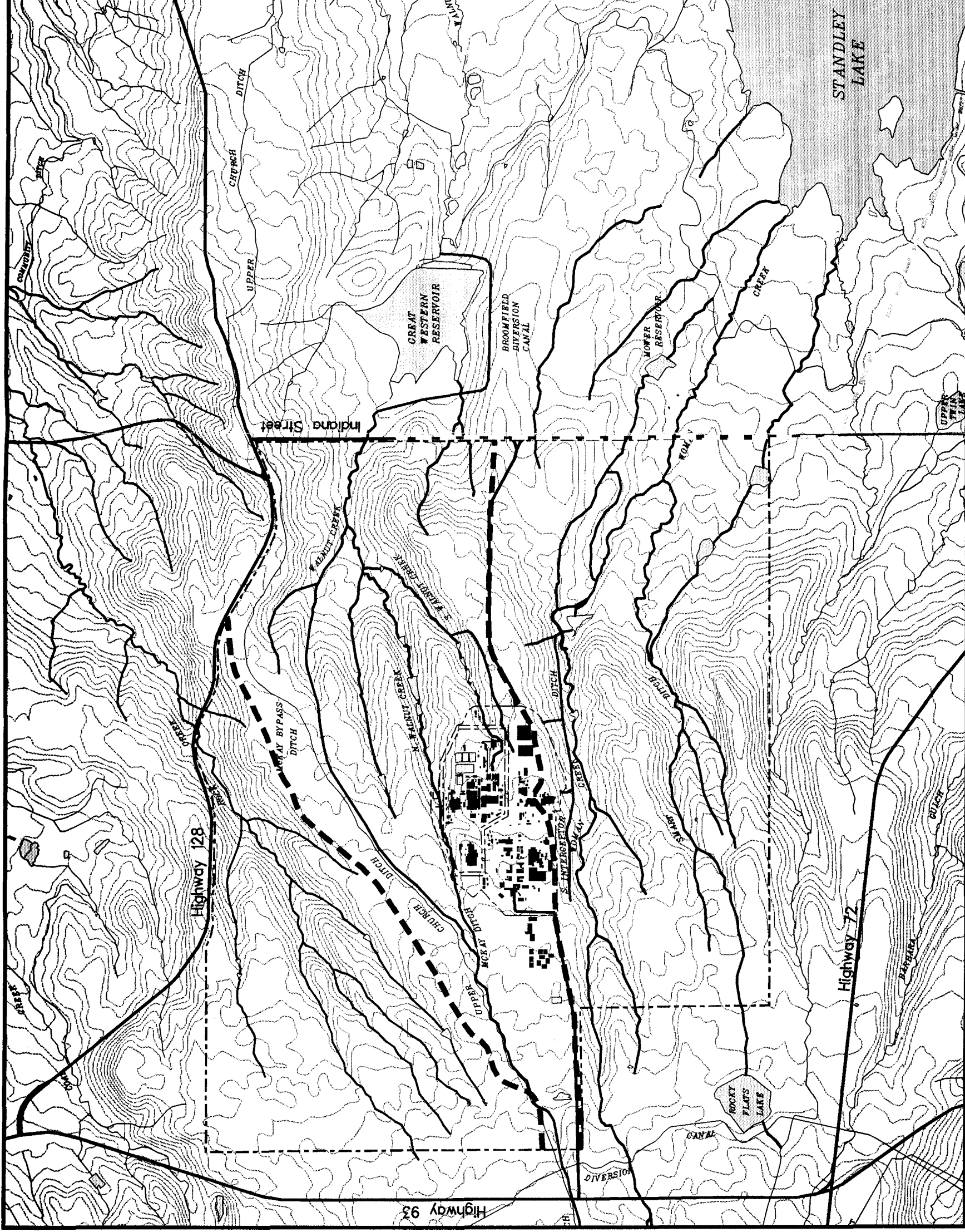
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(M2) Site-wide Conceptual Model

Drainage Basins
in the
Rocky Flats
Environmental Technology Site
Area

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Figure 1-2



EXPLANATION

General Segment Classification

- Stream Gains Year-Round
- Stream Gains During Spring (December - March or April) Losses Rest of Year
- Stream Losses Year-Round
- Stream Experiences a Gain For 2 Months or Less During Year, Losses Rest of Year
- Creek Not Classified Due to Inadequate or Uncalibrated Data

Measurement Location

Surface Water Impoundments

Buildings

Streams and Drainages

Paved Roads

Dirt Roads

Rocky Flats Plant Site and Security Zone Boundaries

Rocky Flats

Site Boundary



Scale = 1 : 16200



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TM2 - Stewardship Conceptual Model

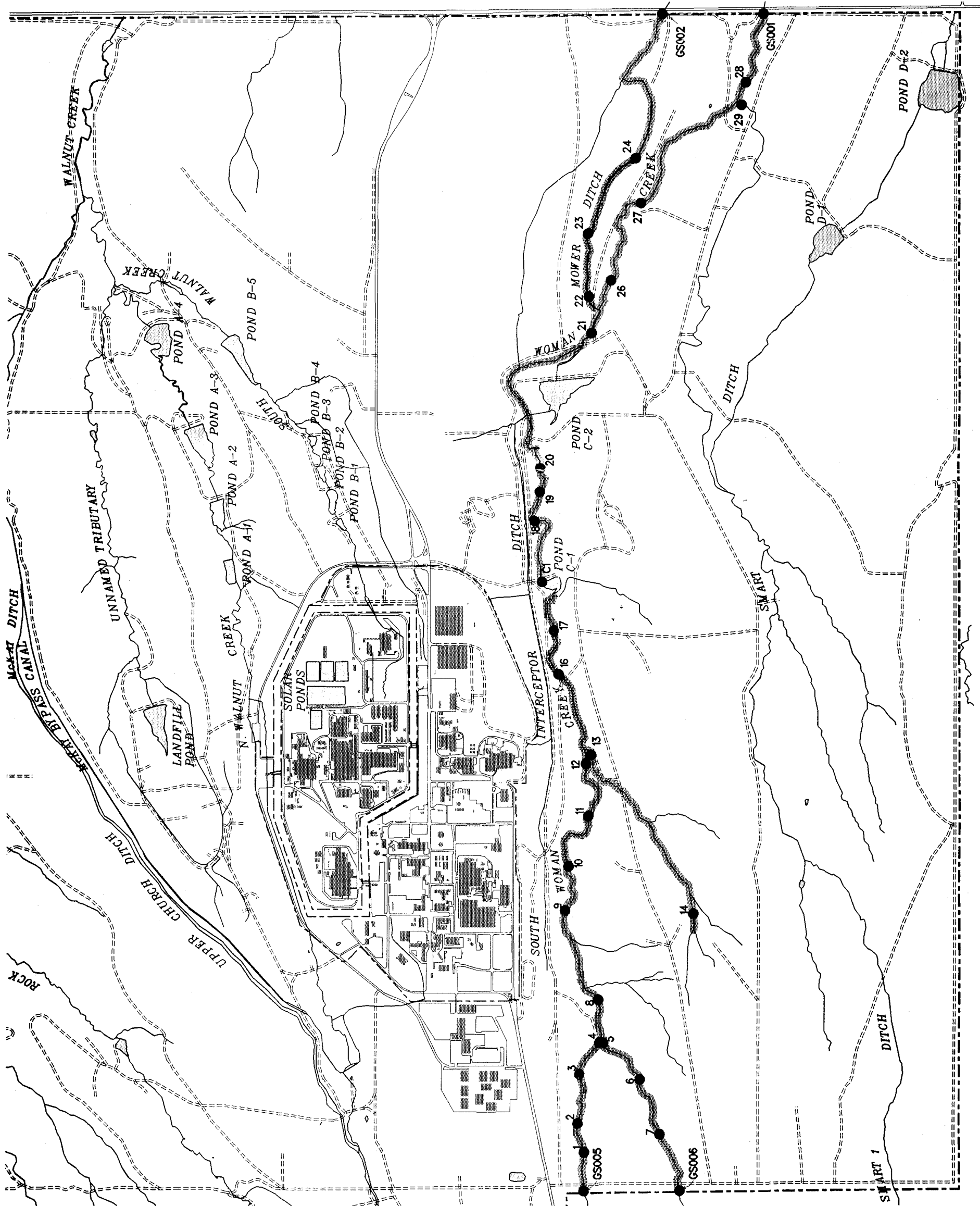
Woman Creek

Infiltration/Exfiltration

Stream Segment Classification

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Figure 2-6



EXPLANATION

- Drainage Basin Boundary
- Rock Creek Drainage
- Walnut Creek Drainage
- Woman Creek Drainage
- Central Avenue
- Dirt Road
- Streams and Drainages
- Security Fences

Lakes and Ponds

- IHSSs within Operable Unit 1
- IHSSs within Operable Unit 2
- IHSSs within Operable Unit 4
- IHSSs within Operable Unit 5
- IHSSs within Operable Unit 6
- IHSSs within Operable Unit 7
- IHSSs within Operable Unit 8
- IHSSs within Operable Unit 9
- IHSSs within Operable Unit 10
- IHSSs within Operable Unit 11
- IHSSs within Operable Unit 12
- IHSSs within Operable Unit 13
- IHSSs within Operable Unit 14
- IHSSs within Operable Unit 15
- IHSSs within Operable Unit 16

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TM2 - Sitewide Conceptual Model

Individual Hazardous

Substance Sites

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Figure 3-1

Scale
0 Feet 1600 3200

